Advanced Java

Daniel Hinojosa

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JShell

Introducing JShell

- Java Shell tool (JShell) is an interactive tool for learning the Java programming language and prototyping Java code
- Read-Evaluate-Print Loop (REPL)
- Evaluates Expressions as they are entered
- JShell accepts Java
  - statements
  - variables
  - methods
  - `class` definitions
  - `import` definitions
  - expressions

Reasons for JShell

- Trial of code before implementation
- Establish and communicate ideas with code
- Bring production code and dissect problems
- Take ideas or fixes back to the IDE

JShell Prerequisites

- JDK 9 or higher

Starting JShell

```
% jshell
```

```
|  Welcome to JShell -- Version 10
|  For an introduction type: /help intro

jshell>
```

JShell in verbose mode

- `-v` will enter you in verbose mode
- Full description of actions performed within JShell

```
% jshell -v
```

Trying out JShell

- Notice there are no semicolons in using JShell when it deals with *some* assignments
- Later versions of Java can make using of `var` same in JShell

```
jshell> var list = List.of(3,4,5,6)
list ==> [3, 4, 5, 6]

jshell> var mapped = list.stream().map(x -> x +
1).collect(Collectors.toList())
mapped ==> [4, 5, 6, 7]

jshell>
```

Replacing Variables in JShell

In this mode you have the availability to reassign a variable in JShell

```
jshell> var x = List.of(1,2,3,4)
x ==> [1, 2, 3, 4]
|  created variable x : List<Integer>

jshell> var x = 30
x ==> 30
|  replaced variable x : int
|    update overwrote variable x : List<Integer>
```

`final` is ignored

- The keyword `final` is ignored as a top level assignment within JShell
- If the verbose is turned on in JShell using `-v` you can review the message

```
jshell> final var d = 30
|  Warning:
|  Modifier 'final'  not permitted in top-level declarations, ignored
|  final var d = 30;
|  ^---^
d ==> 30
|  created variable d : int
```

Scratch Variable

- If you do not create a variable name, one will be created for you
- This is called a *scratch variable*
- It is assigned with a variable `$n` where n is a monotonically increasing integer

```
jshell> 2 + 2
$3 ==> 4
|  created scratch variable $3 : int
```

It can then be subsequently called by that variable

```
jshell> $3 + 2
$4 ==> 6
|  created scratch variable $4 : int
```

Creating methods

- Methods can also be created *without* a surrounding `class`
- They can then be invoked afterwards by name with a surrounding `class`

```
jshell> public String times(int n, String s) {
   ...>    StringBuilder sb = new StringBuilder();
   ...>    for (int i = 0; i < n; i++) {
   ...>       sb.append(s);
   ...>    }
   ...>    return sb.toString();
   ...> }
```

Invocation can then be invoked using standard Java:

```
jshell> times(3, "Foo")
$6 ==> "FooFooFoo"
|  created scratch variable $6 : String
```

Changing method definitions

- If you want to rewrite a method, you can do so by just creating a different implementation
- If you have `-v` verbose mode on, this will show that you are replacing the definition

```
jshell> public String times(int n, String s) {
   ...>   return IntStream.range(0, n).boxed()
   ...>           .map(x -> s).collect(Collectors.joining());
   ...> }
|  modified method times(int,String)
|    update overwrote method times(int,String)
```

Creating a `class`

- Much like a method, a `class` can be creating in JShell
- Merely type in the declaration and use the class at will

```
jshell> public class Country {
   ...>    private String name;
   ...>    private String capital;
   ...>    public Country (String name, String capital) {
   ...>      this.name = name;
   ...>      this.capital = capital;
   ...>    }
   ...>    public String toString() {
   ...>      return "Country {" + name + ", " + capital + "}";
   ...>    }
   ...> }
|  created class Country
```

Subsequently, you can then instantiate the class

```
jshell> var china = new Country("China", "Beijing");
china ==> Country {China, Beijing}
|  created variable china : Country

jshell> var poland = new Country("Poland", "Warsaw");
poland ==> Country {Poland, Warsaw}
|  created variable poland : Country
```

Making a mistake

If you make a mistake, you can hit <**UP-arrow**> and edit the previous unrunnable code

```
jshell> public String times(int n, String s) {
   ...>    StringBuilder sb = new StringBuilder()
   ...>    for (int i = 0; i < n; i++) {
   ...>       sb.append(s);
   ...>    }
   ...>    return sb.toString()
   ...> }
|  Error:
|  ';' expected
|     StringBuilder sb = new StringBuilder()
|                                           ^
|  Error:
|  ';' expected
|     return sb.toString()
|
```

- Hitting the <**UP-arrow**> key, it gives you the ability to edit again
- Typing <**Return**> anywhere in the code edit section will execute the method

```
jshell> public String times(int n, String s) {
   ...>    StringBuilder sb = new StringBuilder();
   ...>    for (int i = 0; i < n; i++) {
   ...>       sb.append(s);
   ...>    }
   ...>    return sb.toString()
   ...> }
| created method times(int,String)
```

Analyzing an `Exception`

- You can trace the root of the `Exception` by:
  - Reading the stack trace
  - Tracing the stack trace to the pre ...> return x / y; ...> } | created method divide(int,int) jshell> divide(5, 0) | java.lang.ArithmeticException thrown: / by zero | at divide (#1:2) | at (#2:1)

jshell> /list

```
1 : int divide(int x, int y) {
return x / y;
}
2 : divide(5, 0)
```

Running an Editor

- You can edit any code using `/edit` command along with a declaration.
- Declarations can either be `class`, method, or variable

Edit `Country`, in this case it is a `class`

```
jshell> /edit Country
```

This will in turn open an editor so that you can edit fully with full cursor support

Figure 1. Standard Editor in JShell

Running your own editor

```
jshell> /set editor vi
```

Resetting your editor

```
jshell> /set editor -default
```

Typical Commands

- `/vars` will show all variables bound
- `/methods` will show all methods bound

- `/types` will show all types, e.g. classes
- `/list` shows a list of entered "snippets"

Viewing Commands

- We can view the possible list of commands by typing `/` and then <**TAB**>

```
jshell> /
/!          /?          /drop       /edit
/env        /exit       /help       /history
/imports    /list       /methods    /open
/reload     /reset      /save       /set
/types      /vars

<press tab again to see synopsis>

jshell> /
```

Typical Commands

- `/vars` will show all variables bound
- `/methods` will show all methods bound
- `/types` will show all types, e.g. classes
- `/list` shows a list of entered "snippets"

Tab Completion

Press <**TAB**> after some code to see some auto-complete alternatives

```
jshell> System.out.
append(        checkError()   close()        equals(
flush()        format(        getClass()     hashCode()
notify()       notifyAll()    print(         printf(
println(       toString()     wait(          write(
```

Type some more of the signature and get documentation

```
jshell> System.out.format(
Signatures:
PrintStream PrintStream.format(String format, Object... args)
PrintStream PrintStream.format(Locale l, String format, Object... args)

<press tab again to see documentation>
```

Pressing <**TAB**> again will show the full documentation

Snippet Transformation

- When invoking the keys combination of <**SHIFT**>+<**TAB**>, you can then use the following to transform your line
  - **m** will create a method
  - **v** will create a variable
  - **i** will provide a selection of `import` for a `package` of a class

Variable Snippet Transformation

- Given that we have already typed the following
- And our cursor is at the end of the line
- We can type <**SHIFT**>+<**TAB**> and then **v** to create a variable
- The cursor will be in a position to create the variable

```
jshell> new BigInteger("302021")
```

- After <**SHIFT**>+<**TAB**> and then <**v**>
  - The cursor will be positioned before the `=`
  - You now have the opportunity to enter a variable name

```
jshell> BigInteger  = new BigInteger("302021")
```

If we named it `i`, this would result in...

```
jshell> BigInteger i = new BigInteger("302021")
```

Method Snippet Transformation

- After creating snippet and our cursor is at the end of the line
- We can type <**SHIFT+TAB**> and then <**m**> to create a method
- The cursor will be in a position to create the method
- This will only work if all variables can be resolve

Establishing a variable

```
jshell> BigInteger i = new BigInteger("302021")
i ==> 302021
|  created variable i : BigInteger
```

We reference `i` and we realize we want as a method

```
jshell> i.add(new BigInteger("4")
```

- The following will give you the opportunity to name the method
- It will place the cursor before the `()`

After **<SHIFT+TAB>** *and* **<m>**

```
jshell> BigInteger () { return i.add(new BigInteger("4")); }
```

Import Snippet Transformation

- **<SHIFT+TAB>** and **<i>** will provide choices for `import` if it is not in the *java.base* module
- Type the `class` you need and at the end **<SHIFT+TAB>** and **<i>**.
- Select the package you wish to import

<SHIFT+TAB> *and* **<i>** *after typing* `DriverManager`

```
jshell> DriverManager
0: Do nothing
1: import: java.sql.DriverManager
Choice:
```

Input Line Navigation

Editing is supported for editing:

- The current line
- Accessing the history through previous sessions of JShell.
- **<CTRL>** and **<META>** key are used in key combinations.

Meta key is a key like the Windows key or Apple key, if not available, then use the **<ALT>** key

Editing Navigation

- When navigating forwards and backwards within a line:
  - Use the **<RIGHT-Arrow>** and **<LEFT-Arrow>**
  - or, **<CTRL+B>** or **<CTRL+F>**
- When bringing up previous snippets and commands use **<UP-Arrow>**
- If the previous commands or snippets contains multiple lines you can edit that line with **<UP-Arrow>** or **<DOWN-Arrow>**

Additional Keys for Editing Navigation

Keys	Action
<Return>	Enters the current line
<LEFT-arrow>	Moves backward one character
<RIGHT-arrow>	Moves forward one character
<UP-arrow>	Moves up one line, backward through history
<DOWN-arrow>	Moves down one line, forward through history
<CTRL+A>	Moves to the beginning of the line
<CTRL+E>	Moves to the end of the line
<META+B>	Moves backward one word
<META+F>	Moves forward one word

Setting the Classpath

- You can use external code that is accessible through the class path in your JShell session.
- Use `--class-path` to load external directories and jar files

```
% jshell --class-path myOwnClassPath
```

While in an already loaded session you can use `/env --class-path`

```
jshell> /env --class-path myOwnClassPath
| Setting new options and restoring state.
```

To view the current classpath:

```
jshell> /env
|     --class-path guava-27.0.1-jre.jar
```

Scripting

- A JShell script is a sequence of snippets and JShell commands in a file, one snippet or command per line.
- Scripts can be a local file, or one of the following predefined scripts:

Script Name	Script Contents
DEFAULT	Includes commonly needed import declarations. This script is used if no other startup script is provided.

PRINTING	Defines JShell methods that redirect to the `print`, `println`, and `printf` methods in `PrintStream`.
JAVASE	Imports the core Java SE API defined by the `java.se` module, which causes a noticeable delay in starting JShell due to the number of packages.

Startup Scripts

- The default startup script has common imports, e.g. `java.lang`
- You can create custom imports as needed
- Startup scripts are loaded everytime:
  - JShell is started
  - When `/reset`, `/reload`, or `/env` commands are invoked
  - The `DEFAULT` script is used by default

Setting up the Startup Script

- You can set the startup script using the following script
- This will only be active in the current session

```
jshell> /set start mystartup.jsh
jshell> /reset
| Resetting state.
jshell
```

You can retain the setup using `-retain` for subsequent sessions

```
jshell> /set start -retain DEFAULT PRINTING
```

Showing what has been retained

Use `/set start` with no arguments to show startup scripts

```
jshell> /set start
|  /set start -retain DEFAULT PRINTING
|  ---- DEFAULT ----
|  import java.io.<strong>;
|  import java.math.</strong>;
|  import java.net.<strong>;
|  import java.nio.file.</strong>;
```

Start Multiple Scripts from Command Line

- If starting from your shell command line, you can use the `--startup` flag
- This will establish startup scripts when first running `jshell`

```
% jshell --startup DEFAULT --startup PRINTING
```

Creating Scripts

- Scripts can be created in an editor or generated in JShell
- To save the JShell session, use either of the following:

```
jshell> /save mysnippets.jsh
```

Saves the history of all of the snippets and commands, both valid and invalid

```
jshell> /save -history myhistory.jsh
```

Saves the contents of the current startup script setting to *mystartup.jsh*.

```
jshell> /save -start mystartup.jsh
```

Loading Scripts

Load a script when first starting JShell

```
% jshell mysnippets.jsh
```

Within JShell a script can be loaded with `/open`

```
jshell> /open mysnippets.jsh
```

Exiting JShell

```
jshell> /exit
```

Where to find more information

- We covered some of the major functionality of JShell

- More fine-grained information can be found in the Official JShell Documentation

Lab: JShell

Step 1: Launch JShell in verbose mode

Step 2: Create a method or `class` that given a `List<String>` of people's name it would return a random winner. Use `java.util.Random` for the randomization

Step 3: Create variables `thirdPlace`, `secondPlace` and `firstPlace` that will return the winners from the `List` of `String`

Step 4: Exit the JShell

Setup

Project Check

Before we begin it is assumed that all of you have the following tools installed:

- JDK 12 or 13 (latest java is 13)
- Maven 3.6.2

To verify that all your tools work as expected

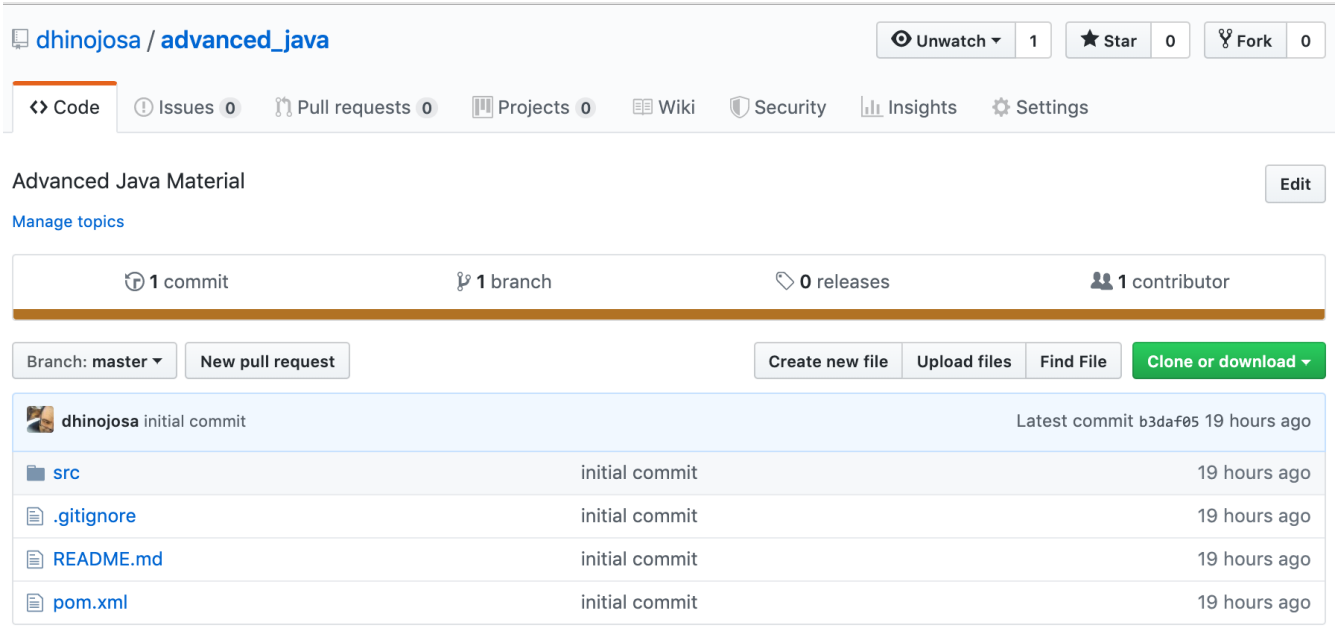
```
% javac -version
javac 13

% java -version
java version "13"
Java(TM) SE Runtime Environment (build 1.8.0_13-b17)
Java HotSpot(TM) 64-Bit Server VM (build 25.65-b01, mixed mode)

% mvn -v
Apache Maven 3.6.2 (bb52d8502b132ec0a5a3f4c09453c07478323dc5; 2015-11
-10T09:41:47-07:00)
Maven home: /usr/lib/mvn/apache-maven-3.6.2
Java version: 13, vendor: Oracle Corporation
Java home: /usr/lib/jvm/jdk13/jre
Default locale: en_US, platform encoding: UTF-8
OS name: "linux", version: "4.4.0-34-generic", arch: "amd64", family:
"unix"
```

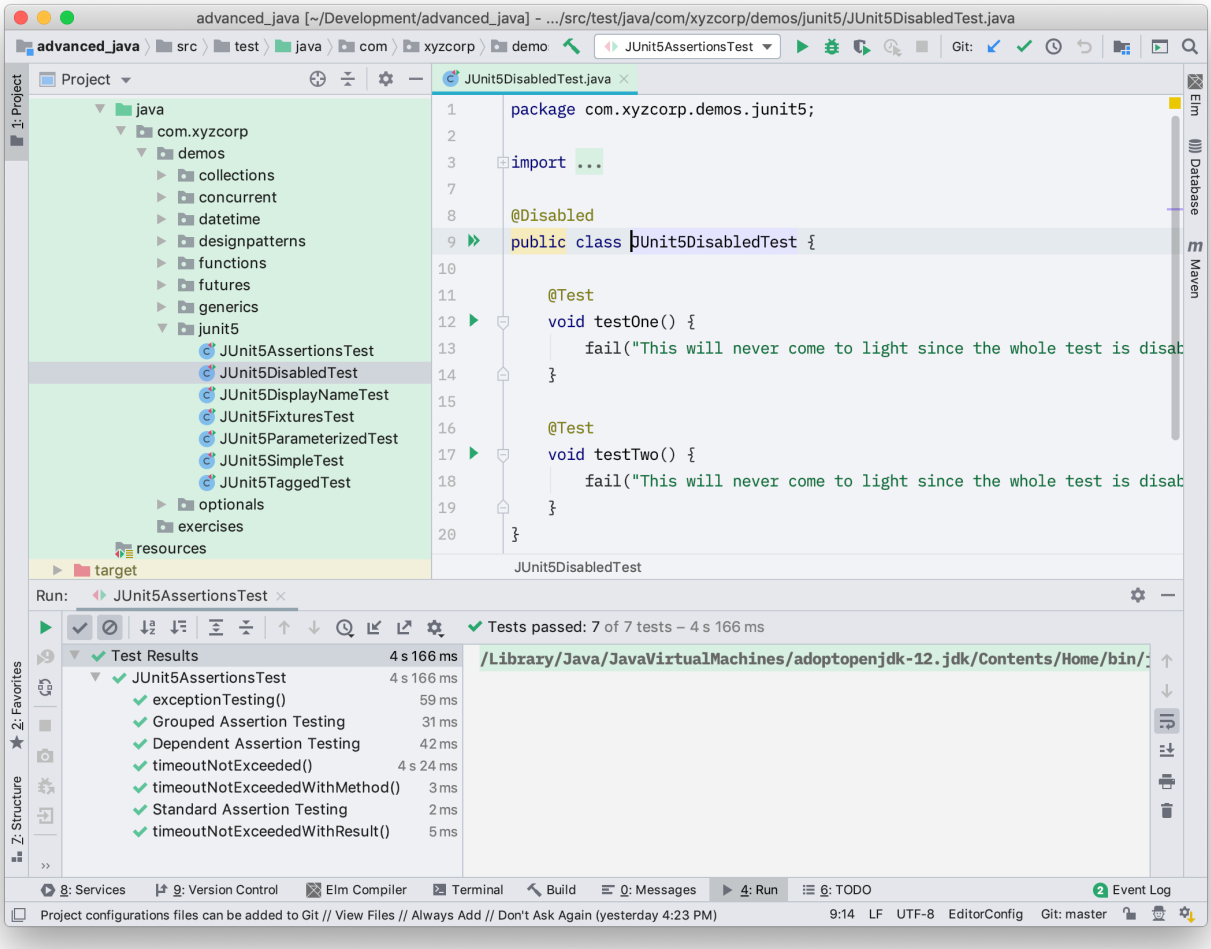
Download the Project

From https://github.com/dhinojosa/advanced_java download the project .zip file and extract it into your favorite location or if you know how to use git, then clone the project into your favorite location.



Opening Project in IntelliJ

Once *advanced_java* is downloaded and extracted or cloned to your favorite location, In IntelliJ Open The Project, IntelliJ will recognize it as a Maven project and you are good to go.

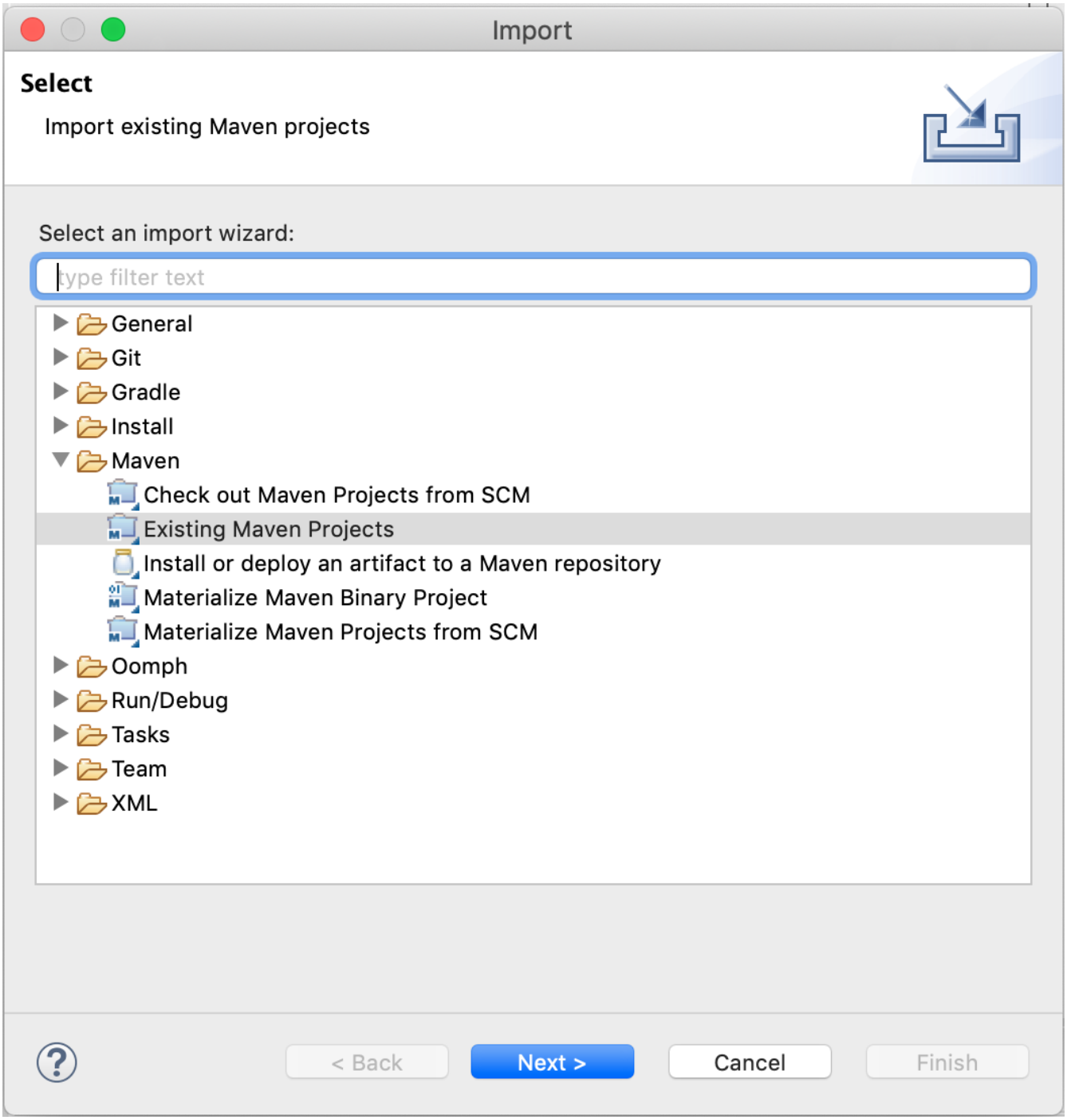


Opening the project in Eclipse

Once downloaded and extracted:

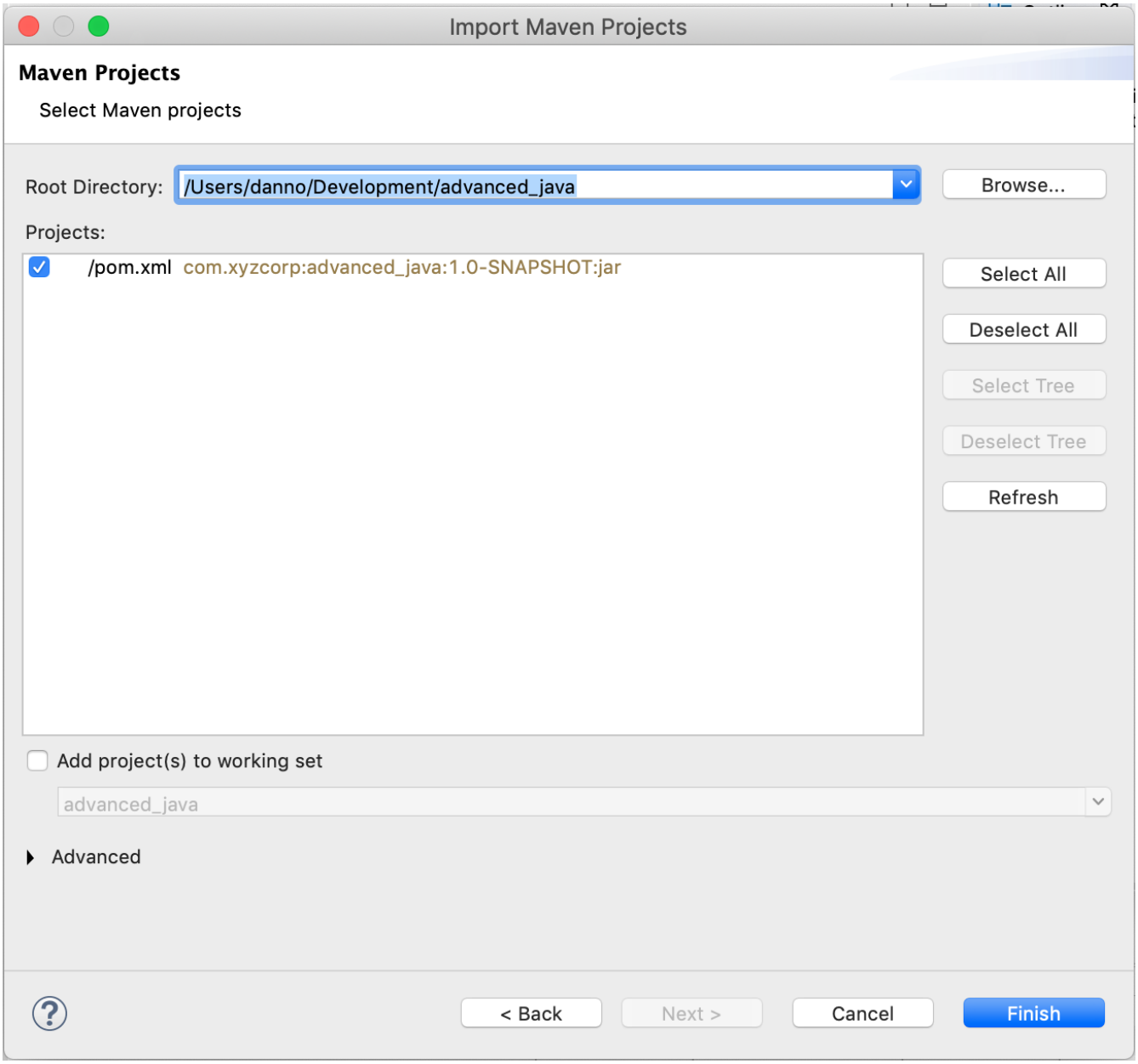
Step 1: Select *File* > *Import Project* in the menu.

Step 2: In the following dialog box:



- Open the *Maven* category
- Select *Import Existing Maven Projects*

Step 3:



- Click the *Browse:* button next to *Root Directory*
- Select the location of your ***advanced_java*** directory.

Step 4: Click *Finish*

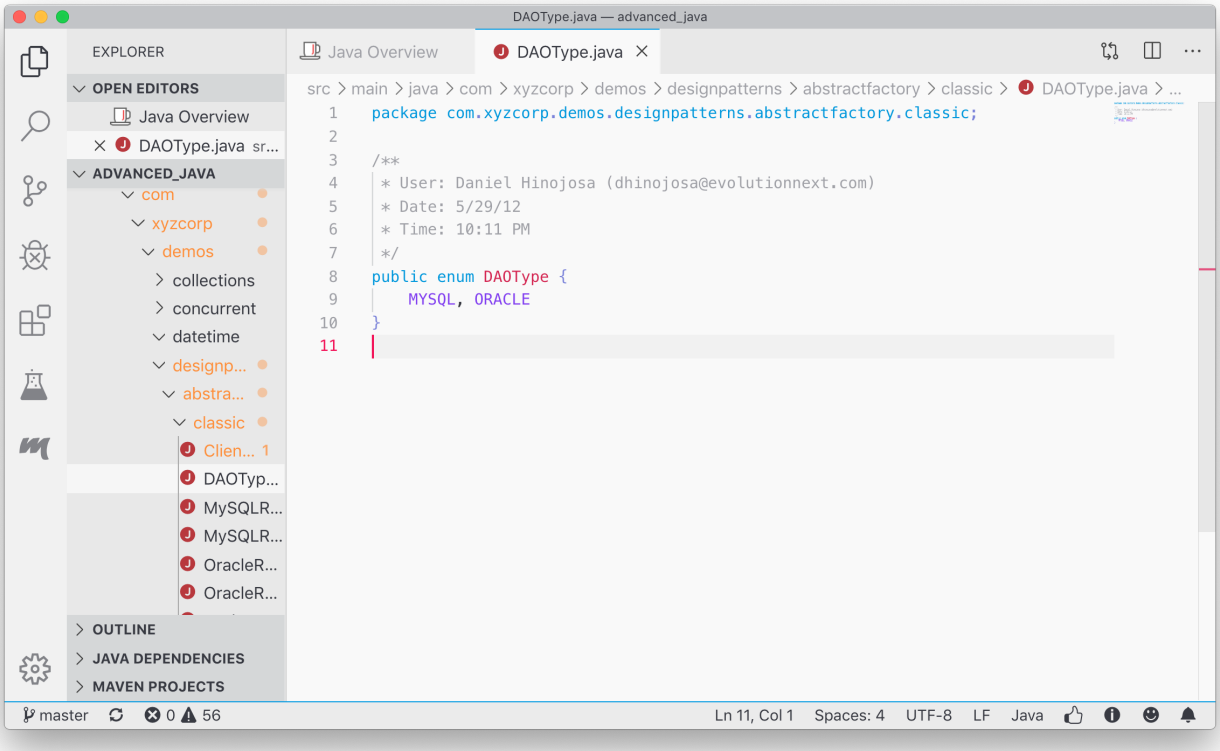
Opening the project in VSCode

Once downloaded and extracted:

Step 1: In a terminal, go to the *advanced_java* directory

Step 2: Run `code .` in the directory

```
% code .
```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xyzcorp
demos
collections
concurrent
datetime
designp...
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classic
Clien... 1
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MySQLR...
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OracleR...
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Java Overview
DAOType.java
src > main > java > com > xyzcorp > demos > designpatterns > abstractfactory > classic > DAOType.java > ...
1 package com.xyzcorp.demos.designpatterns.abstractfactory.classic;
2
3 /**
4 * User: Daniel Hinojosa (dhinojosa@evolutionnext.com)
5 * Date: 5/29/12
6 * Time: 10:11 PM
7 */
8 public enum DAOType {
9 MYSQL, ORACLE
10 }
11
master
0 56
Ln 11, Col 1
Spaces: 4
UTF-8
LF
Java

Lambdas

About Java 8 Lambdas

Functional Interface Definition

> A functional interface is any interface that contains only one abstract method. (A functional interface may contain one or more default methods or static methods.) Because a functional interface contains only one abstract method, you can omit the name of that method when you implement it.

(`equals` is an explicit declaration of a concrete method inherited from `Object` that, without this declaration, would otherwise be implicitly declared.)

Default Methods

- Enable you to add new functionality to the `interface` of your libraries
- Ensure binary compatibility with code written for older versions of those `interface`.
- Comes closer to have "concrete" method in an "interface" by composing other `abstract` methods.

Default Method Arbitrary Example

```
public interface Human {
   public String getFirstName();
   public String getLastName();
   default public String getFullName() {
     return String.format("%s %s",
        getFirstName(), getLastName());
   }
}
```

Defining `MyPredicate`

- It's an interface
- One `abstract` method: `test`
- `default` methods don't count (More on that later)
- `static` methods don't count
- Any methods inherited from `Object` don't count either.

src/main/java/com.xyzcorp.demos.functions.MyPredicate

```
package com.xyzcorp;

public interface MyPredicate<T> {
   public boolean test(T item);
}
```

Conclusion: We can omit the name when we implement it.

Functional `filter`

> Filter is a higher-order function that processes a data structure (usually a list) in some order to produce a new data structure containing exactly those elements of the original data structure for which a given predicate returns the boolean value true.

Wikipedia: Map (higher-order function)

Functional `filter` by example

- Given List of `list`: `[1,2,3,4]`
- Given a function `f`: `x → x % 2 == 0`
- When calling `filter` on a `list` with `f`: `[1,2,3,4].filter(f)`
- Then a copy of the `list` should return: `[2,4]`

Using `MyPredicate`

src/main/java/com.xyzcorp.functions.Functions#myFilter

```
public static <T> List<T> myFilter (List<T> list, MyPredicate<T>
predicate) {
    ArrayList<T> result = new ArrayList<T>();
    for (T item : list) {
        if (predicate.test(item)) {
            result.add(item);
        }
    }
    return result;
}
```

This is the functional `filter`

Testing `MyPredicate`

src/test/java/com.xyzcorp.demos.functions.FunctionsTest#testMyFilter

```
List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15,
                                      19, 21, 33, 78, 93, 10);
List<Integer> filtered = Functions.myFilter(numbers,
   new MyPredicate<Integer>() {
       @Override
       public boolean test(Integer item) {
           return item % 2 == 0;
       }
   });
System.out.println(filtered);
```

Here we are defining what the `Predicate` will do when sent into `filter`.

Convert `MyPredicate` into a Lambda

src/test/java/com.xyzcorp.demos.functions.FunctionsTest#testMyFilter

```
List<Integer> numbers =
   Arrays.asList(2, 4, 5, 1, 9, 15,
                 19, 21, 33, 78, 93, 10);
List<Integer> filtered =
   Functions.myFilter(numbers,
      item -> item % 2 == 0);
System.out.println(filtered);
```

Defining `MyFunction`

src/main/java/com.xyzcorp.demos.functions.MyFunction

```
public interface MyFunction<T, R> {
    public R apply(T t);
}
```

Functional `map`

> Applies a given function to each element of a list, returning a list of results in the same order. It is often called apply-to-all when considered in functional form.

Wikipedia: Map (higher-order function)

Functional `map` by example

1. Given List of `list`: `[1,2,3,4]`
2. Given a function `f`: `x → x + 1`
3. When calling `map` on a `list` with `f`: `[1,2,3,4].map(f)`
4. Then a copy of the `list` should return: `[2,3,4,5]`

Using `MyFunction`

src/main/java/com.xyzcorp.demos.functions.Functions#myMap

```
public static <T, R> List<R> myMap(List<T> list, MyFunction<T, R>
myFunction) {
    ArrayList<R> result = new ArrayList<>();
    for (T t : list) {
        result.add(myFunction.apply(t));
    }
    return result;
}
```

Testing `MyFunction`

src/test/java/com.xyzcorp.demos.functions.FunctionsTest#testMyMap

```
List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15, 19,
                                      21, 33, 78, 93, 10);
List<Integer> mapped = Functions.myMap(numbers,
  new MyFunction<Integer, Integer>() {
    @Override
    public Integer apply(Integer item) {
        return item + 2;
    }
});
System.out.println(mapped);
```

Convert `MyFunction` into a Lambda

src/test/java/com.xyzcorp.demos.functions.FunctionsTest#testMyMap

```
List<Integer> numbers = Arrays.asList(4, 5, 7, 8);
List<Integer> mapped = Functions.myMap(numbers, t -> t + 2);
```

Functional `flatMap`

> Applies a given function to each element of a list, returning a list of results in the same order. It is often called apply-to-all when considered in functional form.

Wikipedia: Map (higher-order function)

Functional `flatMap` by example

1. Given List of `list`: `[1,2,3,4]`
2. Given a function `f`: `x -> [x - 1, x, x + 1]`
3. When calling `flatMap` on a `list` with `f`: `[1,2,3,4].flatMap(f)`
4. Then a copy of the `list` should return: `[0, 1, 2, 1, 2, 3, 2, 3, 4, 3, 4, 5]`

Using `MyFunction` with `flatMap`

src/main/java/com.xyzcorp.demos.functions.Functions#myFlatMap

```
public static <T, R> List<R> myFlatMap(List<T> list, MyFunction<T, List
<R>> myFunction) {
    ArrayList<R> result = new ArrayList<>();
    for (T t : list) {
        List<R> application = myFunction.apply(t);
        result.addAll(application);
    }
    return result;
}
```

Testing `MyFunction`

src/test/java/com.xyzcorp.demos.functions.FunctionsTest#testMyMap

```
List<Integer> numbers = Arrays.asList(4, 5, 7, 8);
List<Integer> mapped = Functions.myFlatMap(numbers,
    t -> List.of(t - 1, t, t + 1));
```

Defining `MyConsumer`

src/main/java/com.xyzcorp.demos.functions.MyConsumer.java

```
package com.xyzcorp;

public interface MyConsumer<T> {
   public void accept(T item);
}
```

Notice that it does not return anything

Functional `forEach`

> Performs an action on each element returning nothing or `void`, a sink

Functional `forEach` by example

1. Given List of `list`: `[1,2,3,4]`
2. Given a function `f`: `x -> System.out.println(x)`
3. When calling `forEach` on a `list` with `f`: `[1,2,3,4].forEach(f)`
4. Then `void` is returned. This is called a side effect.

Using `MyConsumer`

src/main/java/com.xyzcorp.demos.functions.Functions#myForEach

```
public static <T> void myForEach(List<T> list, MyConsumer<T> myConsumer)
{
    for (T t : list) {
        myConsumer.accept(t);
    }
}
```

Testing `MyConsumer`

src/test/java/com.xyzcorp.demos.functions.FunctionsTest#testMyForEach

```
List<Integer> numbers = Arrays.asList(4, 5, 7, 8);
Functions.myForEach(numbers, new MyConsumer<Integer>() {
    @Override
    public void accept(Integer x) {
        System.out.println(x);
    }
});
```

Convert `MyConsumer` into a Lambda

src/test/java/com.xyzcorp.demos.functions.FunctionsTest#testMyForEach

```
List<Integer> numbers = Arrays.asList(4, 5, 7, 8);
Functions.myForEach(numbers, x -> System.out.println(x));
```

A Detour with Method References

- When a lambda expression does nothing but call an existing method
- It's often clearer to refer to the existing method by name.
- Works with lambda expressions for methods that already have a name.

Types of Method References

Table 1. Types of Method References

Kind	Example
Reference to a static method	`ContainingClass::staticMethodName`
Reference to an instance method of a particular object	`containingObject::instanceMethodName`
Reference to an instance method of an arbitrary object of a particular type	`ContainingType::methodName`
Reference to a constructor	`ClassName::new`

`forEach` with a method reference

Before:

src/test/java/com.xyzcorp.demos.functions.FunctionsTest#testMyForEach

```
List<Integer> numbers = Arrays.asList(4, 5, 7, 8);
Functions.myForEach(numbers, new MyConsumer<Integer>() {
    @Override
    public void accept(Integer x) {
        System.out.println(x);
    }
});
```

With a lambda:

src/test/java/com.xyzcorp.demos.functions.FunctionsTest#testMyForEach

```
List<Integer> numbers = Arrays.asList(4, 5, 7, 8);
Functions.myForEach(numbers, x -> System.out.println(x));
```

After:

src/test/java/com.xyzcorp.demos.functions.FunctionsTest#testMyForEach

```
List<Integer> numbers = Arrays.asList(4, 5, 7, 8);
Functions.myForEach(numbers, System.out::println);
```

Although confusing, in `System.out`, `out` is a `public final static` variable. Therefore, `println` is a non-static method of `java.io.PrintStream`. This is an instance method of an object.

Static method with a method reference

Before:

src/test/java/com.xyzcorp.demos.functions.FunctionsTest#testMethodReferenceAStaticMethod

```
List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15, 19,
        21, 33, 78, 93, 10);
System.out.println(Functions.myMap(numbers, new MyFunction<Integer,
    Integer>() {
    @Override
    public Integer apply(Integer a) {
        return Math.abs(a);
    }
}));
```

With a Lambda:

src/test/java/com.xyzcorp.demos.functions.FunctionsTest#testMethodReferenceAStaticMethod

```
List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15, 19,
                21, 33, 78, 93, 10);
System.out.println(Functions.myMap(numbers, a -> Math.abs(a)));
```

With a Method Reference:

src/test/java/com.xyzcorp.demos.functions.FunctionsTest#testMethodReferenceAStaticMethod

```
List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15, 19,
        21, 33, 78, 93, 10);
System.out.println(Functions.myMap(numbers, Math::abs));
```

Containing Type as a Method Reference

Before:

src/test/java/com.xyzcorp.demos.functions.FunctionsTest#testMethodReferenceAContainingType

```
List<String> words = Arrays.asList("One", "Two", "Three", "Four");
List<Integer> result = Functions.myMap(words, new MyFunction<String,
    Integer>() {
    @Override
    public Integer apply(String s) {
        return s.length();
    }
});
System.out.println(result);
```

With a Lambda:

src/test/java/com.xyzcorp.demos.functions.FunctionsTest#testMethodReferenceAContainingType

```
List<String> words = Arrays.asList("One", "Two", "Three", "Four");
List<Integer> result = Functions.myMap(words, s -> s.length());
System.out.println(result);
```

With a Method Reference:

src/test/java/com.xyzcorp.demos.functions.FunctionsTest#testMethodReferenceAContainingType

```
List<String> words = Arrays.asList("One", "Two", "Three", "Four");
List<Integer> result = Functions.myMap(words, String::length);
System.out.println(result);
```

Owner of the Method Reference

- The owner of the method might be any super type
- Not always the type that you are using

Before:

src/test/java/com.xyzcorp.demos.functions.FunctionsTest#testMethodReferenceAContainingTypeTrickQuestion

```
List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15, 19,
        21, 33, 78, 93, 10);
System.out.println(Functions.myMap(numbers, new MyFunction<Integer,
    String>() {
    @Override
    public String apply(Integer integer) {
        return integer.toString();
    }
}));
```

With a Lambda:

src/test/java/com.xyzcorp.demos.functions.FunctionsTest#testMethodReferenceAContainingType

```
List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15, 19,
        21, 33, 78, 93, 10);
System.out.println(Functions.myMap(numbers, integer -> integer.
toString()));
```

With a Method Reference:

src/test/java/com.xyzcorp.demos.functions.FunctionsTest#testMethodReferenceAContainingType

```
List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15, 19,
        21, 33, 78, 93, 10);
System.out.println(Functions.myMap(numbers, Object::toString));
```

Use your IDE to guide you. It's easier that way.

Method Reference with an Instance

Given a custom TaxRate class:

src/main/java/com.xyzcorp.demos.functions.TaxRate

```
package com.xyzcorp;

public class TaxRate {
    private final int year;
    private final double taxRate;

    public TaxRate(int year, double taxRate) {
        this.year = year;
        this.taxRate = taxRate;
    }

    public double apply(int subtotal) {
        return (subtotal * taxRate) + subtotal;
    }

    //Getters, toString, equals elided
}
```

Before:

src/test/java/com.xyzcorp.demos.functions.FunctionsTest#testMethodReferenceAnInstance

```
List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15, 19,
        21, 33, 78, 93, 10);
TaxRate taxRate2016 = new TaxRate(2016, .085);
System.out.println(Functions.myMap(numbers,
  new MyFunction<Integer, Double>() {
    @Override
    public Double apply(Integer subtotal) {
        return taxRate2016.apply(subtotal);
    }
}));
```

With a Lambda:

src/test/java/com.xyzcorp.demos.functions.FunctionsTest#testMethodReferenceAnInstance

```
List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15, 19,
        21, 33, 78, 93, 10);
TaxRate taxRate2016 = new TaxRate(2016, .085);
System.out.println(Functions.myMap(numbers, subtotal -> taxRate2016
.apply(subtotal)));
```

After:

src/test/java/com.xyzcorp.demos.functions.FunctionsTest#testMethodReferenceAnInstance

```
List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15, 19,
        21, 33, 78, 93, 10);
TaxRate taxRate2016 = new TaxRate(2016, .085);
System.out.println(Functions.myMap(numbers, taxRate2016::apply));
```

Use your IDE to guide you. It's easier that way.

Method Reference with an New Type

Before:

```
List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15, 19,
    21, 33, 78, 93, 10);
System.out.println(Functions.myMap(numbers,
    new MyFunction<Integer, Double>() {
        @Override
        public Double apply(Integer value) {
            return new Double(value);
        }
    }));
```

With A Lambda:

```
List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15, 19,
            21, 33, 78, 93, 10);
System.out.println(Functions.myMap(numbers,
    value -> new Double(value)));
```

After:

```
List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15, 19,
            21, 33, 78, 93, 10);
System.out.println(Functions.myMap(numbers, Double::new));
```

Use your IDE to guide you. It's easier that way.

`new Double` is deprecated in favor of `Double.valueOf(..)`. This was used for demonstration.

Create `MySupplier`

Step 1: In `src/main/java`, create an `interface` in the `com.xyzcorp` package called `MySupplier`

```
package com.xyzcorp;

public interface MySupplier<T> {
   public T get();
}
```

Compare the difference to `MyConsumer`

Create a `myGenerate` in *Functions.java*

Step 1: Create `static` method called `myGenerate` with the following method header which takes a `MySupplier`, and a count, and returns a `List` with `count` number of items where each element is derived from invoking the `Supplier`

```
public static <T> List<T> myGenerate(MySupplier<T> supplier, int count)
{}
```

Step 2: Fill in the method with what you believe a `myGenerate` should look like

Use `myGenerate` in *FunctionsTest.java*

Step 1: Add the following test, `testMyGenerate` to the `FunctionsTests` class:

```
package com.xyzcorp;

import org.junit.Test;

import java.time.LocalDateTime;
import java.util.Arrays;
import java.util.List;

public class FunctionsTest {

    ...

    @Test
    public void testMyGenerate() {
        List<LocalDateTime> localDateTimes =
          Functions.myGenerate(new MySupplier<LocalDateTime>() {
              @Override
              public LocalDateTime get() {
                  return LocalDateTime.now();
              }
          }, 10);
        System.out.println(localDateTimes);
    }
}
```

`LocalDateTime.now()` is from the new Java Date/Time API from Java 8.

Step 2: Convert the `new MySupplier` anonymous instantiation into a lambda using your IDE's faculties

Step 3: Run to verify it all works!

Viewing Consumer, Supplier, Predicate, Function, in the official Javadoc.

https://docs.oracle.com/javase/8/docs/api/java/util/function/package-summary.html

Multi-line Lambdas

Step 1: In ***FunctionsTest.java*** create the following test, `testLambdasWithRunnable` where a `java.lang.Runnable` and `java.lang.Thread` is being created.

```
package com.xyzcorp;

import org.junit.Test;

import java.time.LocalDateTime;
import java.util.Arrays;
import java.util.List;

public class FunctionsTest {

    ...

    @Test
    public void testLambdasWithRunnable() {
        Thread t = new Thread(new Runnable() {
            @Override
            public void run() {
                String threadName =
                        Thread.currentThread().getName();
                System.out.format("%s: %s%n",
                        threadName,
                        "Hello from another thread");
            }
        });
        t.start();
    }
}
```

`Runnable` is an `interface` with one `abstract` method.

Step 2: Convert the `Runnable` into a lambda.

Step 3: Notice how the lambda is created, this is a multi-line lambda.

Closure

- *Lexical scoping* caches values provided in one context for use later in another context.
- If lambda expression closes over the scope of its definition, it is a *closure*.

```
public static Integer foo
        (Function<Integer, Integer> f) {
    return f.apply(5);
}

public void otherMethod() {
    Integer x = 3;
    Function<Integer, Integer> add3 = z -> x + z;
    System.out.println(foo(add3));
}
```

Lexical Scoping Restrictions

- To avoid any race conditions:
  - The variable that is being in enclosed must either be:
    - `final`
    - *Effectively final*. No change can be made after used in a closure.

Closure Error

The following will not work...

```
public static Integer foo
        (Function<Integer, Integer> f) {
    return f.apply(5);
}

public void otherMethod() {
    Integer x = 3;
    Function<Integer, Integer> add3 = z -> x + z;
    x = 10;
    System.out.println(foo(add3));
}
```

Create Duplicated Code

An application for a closure is to avoid repetition.

Step 1: In ***FunctionsTest.java*** create the following test, `testClosuresAvoidRepeats`

```
package com.xyzcorp;

import org.junit.Test;

import java.time.LocalDateTime;
import java.util.Arrays;
import java.util.List;

public class FunctionsTest {

    ...

    @Test
    public void testClosuresAvoidRepeats() {
        MyPredicate<String> stringHasSizeOf4 =
                str -> str.length() == 4;

        MyPredicate<String> stringHasSizeOf2 =
                str -> str.length() == 2;

        List<String> names = Arrays.asList("Foo", "Ramen", "Naan",
"Ravioli");
        System.out.println(Functions.myFilter(names, stringHasSizeOf4));
        System.out.println(Functions.myFilter(names, stringHasSizeOf2));
    }
}
```

Step 2: Notice that `stringHasSize4` and `stringHasSize2` are duplicated.

Refactor Duplicated Code with a Closure

An application for a closure is to avoid repetition.

Step 1: In ***FunctionsTest.java*** change `testClosuresAvoidRepeats` to avoid repeats to look like the following:

```
package com.xyzcorp;

import org.junit.Test;

import java.time.LocalDateTime;
import java.util.Arrays;
import java.util.List;

public class FunctionsTest {

    ...

    public MyPredicate<String> stringHasSizeOf(final int length) {
        return null; //Create your closure here
    }

    @Test
    public void testClosuresAvoidRepeats() {
        List<String> names = Arrays.asList("Foo", "Ramen", "Naan",
"Ravioli");
        System.out.println(Functions.myFilter(names, stringHasSizeOf(
4)));
        System.out.println(Functions.myFilter(names, stringHasSizeOf(
2)));
    }
}
```

Step 2: Inside of `stringHasSizeOf(final int length)` return a `MyPredicate` that *closes* around the length.

Lab: Functions

Step 1: Open *src/test/java/com.xycorp.exercises.function.FunctionExercises*

Step 2: Understand how to write a test with methods, `testSampleWithStandardJUnit` and `testSampleWithStandardJUnitAndAssertJAssertion` in case you are unfamiliar with testing

Step 3: Preferably using Test Driven Development, create a class called `MyTimer` with a static method called `measureTime`. `measureTime` should take a `Supplier` that returns an `Integer` representing how long the lambda will take when executed. `measureTime` should return a custom class called `TimeResult` that will have two methods:

- `getResult` - This will return the result of the lambda
- `getTime` - This will return the result of how long `measureTime` took

Here is an example of what it *may* look like:

```
var result = MyTimer.measureTime(() -> {
    try {
        Thread.sleep(4000);
    } catch (InterruptedException e) {
        e.printStackTrace();
    }
    return 40;
});
```

Step 4: Extra Credit. Make it generic! What if the lambda is not returning an `Integer` can you make this so it uses any type?

`Optional`

Sir Richard Antony Hoare on the `null` reference

> I call it my billion-dollar mistake. It was the invention of the null reference in 1965. At that time, I was designing the first comprehensive type system for references in an object oriented language (ALGOL W). My goal was to ensure that all use of references should be absolutely safe, with checking performed automatically by the compiler. But I couldn't resist the temptation to put in a null reference, simply because it was so easy to implement. This has led to innumerable errors, vulnerabilities, and system crashes, which have probably caused a billion dollars of pain and damage in the last forty years.

`Optional` Defined in Java 8

> A **container object** which may or may not contain a non-null value. If a value is present, `isPresent()` will return `true` and `get()` will return the value.

Optional is **not** `Serializable`

This is a value-based class; use of identity-sensitive operations (including reference equality (`==`), identity hash code, or synchronization) on instances of `Optional` may have unpredictable results and should be avoided.

`Optional` Empty

- The following represents an absence of value
- Fully Generic

```
Optional<Integer> middleName = Optional.empty();
```

`Optional` Non Empty

- The following represents an answer, a full representation of value

```
Optional<String> middleName = Optional.of("Hello");
```

Trapping Something Possibly `null`

- A commonly used technique to trap something that can possibly be `null`
- Returns an `Optional` describing the given value, if non-`null`, otherwise returns an empty `Optional`

src/test/java/com.xyzcorp.demos.optionals.OptionalsTest#testOptionalFromSomethingPossiblyNull

```
String possibleNull = getSomethingRandomlyNull();
Optional<String> optional = Optional.ofNullable(possibleNull);
if (possibleNull == null) assertThat(optional.isPresent()).isFalse();
else assertThat(optional.isPresent()).isTrue();
```

`Optional.get`

- Used to obtain the value of the `Optional`
- Typically the *unsafe way* to do so, although can be useful when known that it is present
  - e.g. after `filter(Optional::isPresent)`

The following returns `40L`

src/test/java/com.xyzcorp.demos.optionals.OptionalsTest#testGettingTheValueAndLucky

```
Optional<Long> optionalLong = Optional.of(40L);
optionalLong.get();
```

The following will throw a `NoSuchElementException`

```
Optional<Long> optionalLong = Optional.empty();
optionalLong.get();
```

Responsible retrieval using `orElse`

- A safe way to retrieve is `orElse` which will retrieve the value
- The following will return `-1`

src/test/java/com.xyzcorp.demos.optionals.OptionalsTest#testGettingTheValueTheGoodWayUsingGetOrElse

```
Optional<Long> optionalLong = Optional.empty();
Long result = optionalLong.orElse(-1L);
```

Lazy Retrieval with a `Supplier`

- Nearly the same as `orElse`

- Lazy alternative with `Supplier`

src/test/java/com.xyzcorp.demos.optionals.OptionalsTest#testGettingTheValueTheGoodWayUsingOrElseGet

```
Optional<Long> optionalLong = Optional.of(40L);
Long result = optionalLong.orElseGet(this::getDefaultAverage);
```

`ifPresentOrElse`

- Functional conditional handling whether present or empty
- First argument is a Consumer of the contained type of the `Optional`
- Second is a `Runnable` of a side effect for the otherwise case
- Perfect for test assertions

src/test/java/com.xyzcorp.demos.optionals.OptionalsTest#testGettingTheValueWithIfPresentOrElse

```
Optional<Long> optionalLong = Optional.of(40L);
optionalLong
    .ifPresentOrElse(
        x -> assertEquals(40L, x),
        () -> System.out.println("Not good"));
```

`Optional` and `map`

- `Optional` has `map` functionality
- Applies function to the value inside of a present `Optional`

```
Optional<Integer> i = Optional.of(40);
Optional<Integer> result = i.map(a -> a * 20);
```

`Optional` and `flatMap`

- `Optional` has `map` functionality
- Applies a function to the value inside that also returns another `Optional` of a present `Optional`

```
Optional<Integer> i = Optional.of(40);
Optional<Integer> j = Optional.of(90);
Optional<Integer> result = i.flatMap(a -> j.map(b -> a * b));
```

`Optional` is not `Serializable`

> This answer is in response to the question in the title, "Shouldn't Optional be Serializable?" The short answer is that the Java Lambda (JSR-335) expert group considered and rejected it. That note, and this one and this one indicate that the primary design goal for Optional is to be used as the return value of functions when a return value might be absent. The intent is that the caller immediately check the Optional and extract the actual value if it's present. If the value is absent, the caller can substitute a default value, throw an exception, or apply some other policy. This is typically done by chaining fluent method calls off the end of a stream pipeline (or other methods) that return Optional values.
>
> It was never intended for Optional to be used other ways, such as for optional method arguments or to be stored as a field in an object. And by extension, making Optional serializable would enable it to be stored persistently or transmitted across a network, both of which encourage uses far beyond its original design goal.

Stack Overflow on `Optional` Serialization

Lab: `Optional`

Step 1: Open *src/test/java/com.xycorp.exercises.optionals.OptionalExercises*

Step 2: Read and understand the two `Map` instances: `europeanCountriesCapitals` and `europeanCapitalPopulation`

Step 3: In the test `testGettingGreeceCurrency`, use `Optional` to safely read from `europeanCountriesCapitals` using `Optional`. Assert that the capital of `Greece` is `Athens`. *Do not use plain* `if` *statements*. This is an exercise for functional programming so use either `map`, `flatMap`, `filter`, `forEach`, or any of the `Optional` methods

Step 4: In the test `testGettingHungaryCurrency`, use `Optional` to safely read from `europeanCountriesCapitals` using Optional. Assert that the capital of `Hungary` is not available. *Do not use plain* `if` *statements*. This is an exercise for functional programming so use either `map`, `flatMap`, `filter`, `forEach`, or any of the `Optional` methods.

Step 5: In the test `testGettingFromNorwayTheCapitalAndPopulation`, use `Optional` to safely read from `europeanCountriesCapitals` given a `String` of `Norway`. Whatever the result from the capital, use that capital to query from `europeanCapitalPopulation` and get the population. Return the pairing of the capital and the population. *Do not use plain* `if` *statements*. This is an exercise for functional programming so use either `map`, `flatMap`, `filter`, `forEach`, or any of the `Optional` methods. Consider creating a custom `Pair` to do so.

Step 6: In the test `testGettingFromGreeceTheCapitalAndPopulation`, use `Optional` to safely read from `europeanCountriesCapitals` given a `String` of `Greece`. Whatever the result from the capital, use that capital to query from `europeanCapitalPopulation` and get the population. Assert that the population of `Greece` is not available for population. *Do not use plain* `if` *statements*. This is an exercise for functional programming so use either `map`, `flatMap`, `filter`, `forEach`, or any of the `Optional` methods. Consider creating a custom `Pair` class to do so.

Step 7: In the test `testGettingFromNorwayTheCountryAndCapitalAndCurrency`, use `Optional` to safely read from `europeanCountriesCapitals` given a `String` of `Norway`. Whatever the result from the capital, use that capital to query from `europeanCapitalPopulation` and get the population. Return a *triplet* of the capital and the population. *Do not use plain* `if` *statements*. This is an exercise for functional programming so use either `map`, `flatMap`, `filter`, `forEach`, or any of the `Optional` methods. Consider creating a custom `Triple` to do so.

Step 8: Refactor aggressively, make the methods look nice.

Step 9: Identify the closures.

Hint. In IntelliJ the closured variables are in purple

JUnit 5

- Latest project for JUnit 5
- Built atop JUnit Classic
- Applies Functional Programming
- Extension set called Jupiter Provides
  - Fixtures
  - Parameterized Tests
  - Tagging
  - more...

Running Tests on the Command Line

```
% mvn test
```

To run a specific test

```
% mvn -Dtest=MyTest test
```

Simple Test

Typical `import`

```
import org.junit.jupiter.api.Test;

import static org.junit.jupiter.api.Assertions.assertEquals;
```

```
public class JUnit5SimpleTest {
    @Test
    public void myFirstTest() {
        assertEquals(2, 1 + 1);
    }
}
```

Standard Assertions

src/test/java/ com.xyzcorp.demos.junit5.JUnit5AssertionsTest#standardAssertions

```
@Test
@DisplayName("Standard Assertion Testing")
void standardAssertions() {
    assertEquals(2, 2);
    assertEquals(4, 4,
       "The optional assertion message is now the last parameter.");
    assertTrue(2 == 2, () ->
       "Assertion messages can be lazily evaluated -- "
       + "to avoid constructing complex messages unnecessarily.");
}
```

Grouped Assertions

src/test/java/ com.xyzcorp.demos.junit5.JUnit5AssertionsTest#groupedAssertions

```
@Test
@DisplayName("Grouped Assertion Testing")
void groupedAssertions() {
    // In a grouped assertion all assertions are executed, and any
    // failures will be reported together.

    Employee e = new Employee("Douglas", "Adams");
    assertAll("person",
            () -> assertEquals("Douglas", e.getFirstName()),
            () -> assertEquals("Adams", e.getLastName())
    );
}
```

Dependent Assertions

```
@Test
@DisplayName("Dependent Assertion Testing")
void dependentAssertions() {
    // Within a code block, if an assertion fails the
    // subsequent code in the same block will be skipped.
    Employee employee = new Employee("Douglas", "Adams");
    assertAll("Employee Properties",
            () -> {
                String firstName = employee.getFirstName();
                assertNotNull(firstName);

                // Executed only if the previous assertion is valid.
                assertAll("first name",
                        () -> assertTrue(firstName.startsWith("D")),
                        () -> assertTrue(firstName.endsWith("s"))
                );
            },
            () -> {
                // Grouped assertion, so processed independently
                // of results of first name assertions.
                String lastName = employee.getLastName();
                assertNotNull(lastName);

                // Executed only if the previous assertion is valid.
                assertAll("last name",
                        () -> assertTrue(lastName.startsWith("A")),
                        () -> assertTrue(lastName.endsWith("s"))
                );
            }
    );
}
```

Exception Testing

```
@Test
void exceptionTesting() {
    Throwable exception = assertThrows(IllegalArgumentException.class,
        () -> {
           throw new IllegalArgumentException("a message");
        }
    );

    assertEquals("a message", exception.getMessage());
}
```

Timeout Testing

```
@Test
void timeoutNotExceeded() {
    // The following assertion succeeds.
    assertTimeout(ofSeconds(5), () -> {
        Thread.sleep(4000);
    });
}
```

```
@Test
void timeoutNotExceededWithResult() {
    // The following assertion succeeds, and
    // returns the supplied object.
    String actualResult = assertTimeout(
        ofSeconds(2), () -> "a result");
    assertEquals("a result", actualResult);
}
```

```
@Test
void timeoutNotExceededWithMethod() {
    Employee employee = new Employee("Carl", "Sagan");
    // The following assertion invokes
    // a method reference and returns an object.
    String lastName = assertTimeout(ofSeconds(2),
       employee::getLastName);
    assertEquals("Sagan", lastName);
}
```

Disabling Tests

Disabling the Test on the class level

```
@Disabled
public class JUnit5DisabledTest {

    @Test
    void testOne() {
        fail("This will never come to light since the whole test is
disabled");
    }

    @Test
    void testTwo() {
        fail("This will never come to light since the whole test is
disabled");
    }
}
```

Disabling the Test on the method level

```
@Test
@Disabled("because I don't want the test to fail")
void failingTest() {
    fail("a failing test");
}
```

Lab: JUnit 5

Step 1: Open *src/test/java/com.xycorp.exercises.junit5.FindSmallestIntegerToZeroTest*

Test Driven Development is defined using the following rules:

1. Quickly add a test.
2. Run all tests and see the new one fail.
3. Make a little change.
4. Run all tests and see them all succeed.
5. Refactor to remove duplication.

Test Driven Development is meant to be done in an incremented fashion, starting small and working your way up in complexity. The goal of Test Driven Development is seek out red bar tests and not necessarily green bar tests

Step 2: Use Test Driven Development and JUnit 5 Parameterized Testing and create a class called `FindSmallestIntegerToZero` with the following specification:

https://cyber-dojo.org

> Given a list of integers find the closest to zero. If there is a tie, choose the positive value.

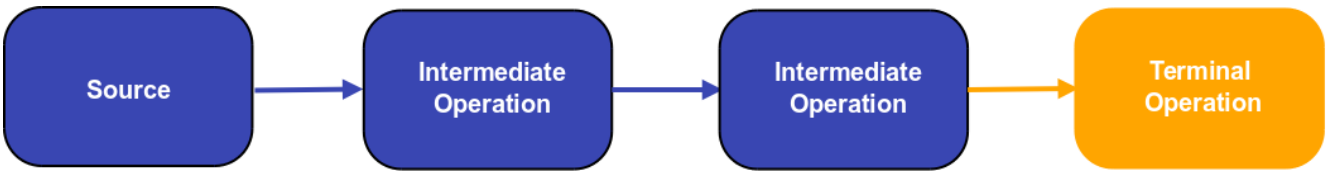
Step 3: Create a test that ensure that the list provided is not `null` using JUnit 5's Exception Handling Assertions

Streams

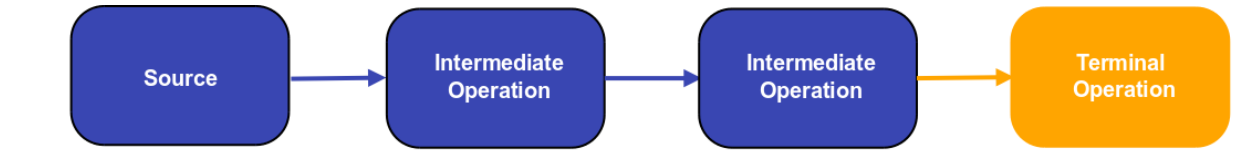
`Streams` differ from Collections in the following ways:

- No storage. A stream is not a data structure that stores elements; instead
- It conveys elements from a source through a pipeline of computational operations
- Sources can include.
  - Data structure
  - An array
  - Generator function
  - I/O channel
- Functional in nature. An operation on a stream produces a result, **but does not modify its source**.
- Intermediate operations are laziness-seeking exposing opportunities for optimization.
- Possibly unbounded. While collections have a finite size, streams need not.
- Short-circuiting operations such as `limit(n)` or `findFirst()` can allow computations on infinite streams to complete in finite time.
- Consumable, The elements of a stream are only visited once during the life of a stream.
- Like an `java.util.Iterator`, a new `Stream` must be generated to revisit the same elements of the source.

Streams Overview



Streams Overview With Code



Creation

Creating a Stream using `of`

- `of` is the fastest way to create a `Stream`
- Does not require an initial collection

- Returns a sequential ordered stream whose elements are the specified values

src/test/java/com.xyzcorp.demos.streams.StreamsTest#createAStreamFromElements

```
Stream<Integer> integerStream = Stream.of(3, 4, 5);
List<Integer> result =
    integerStream
        .map(x -> x + 2)
        .collect(Collectors.toList());
```

Results in:

```
[5, 6, 7]
```

Creating a Stream from a `Collection`

- The `stream()` call converts nearly any `Collection` into a stream
- The stream becomes a pipeline that functional operations can be completed.
- `map` is an intermediate operation
- `collect` is an terminal operation
- The terminal operation will convert the `stream` into a list`
- `Collectors` offers a wide range of different terminal operations
- ***The stream is lazily evaluated until you call a terminal operation***

Creating a Basic Stream from `List`

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testBasicStreamFromList

```
List<Integer> integers = Arrays.asList(1, 4, 5);
List<Integer> result = integers.stream()
     .map(x -> x + 1).collect(Collectors.toList());
```

Results In:

```
[2, 5, 6]
```

Creating a Basic Stream from `Set`

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testBasicStreamFromSet

```
Set<Integer> integers = Set.of(30, 10, 12, 4);
Set<Integer> result =
    integers.stream()
            .map(x -> x + 1)
            .collect(Collectors.toSet());
```

Results In:

```
Set.of(31, 11, 13, 5)
```

`Collectors` Don't Need to Match to the `Stream`

- Once you have `Stream` you can collect it to whatever type you'd like
- Regardless of how you created the `Stream`

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testBasicStreamFromSetToList

```
Set<Integer> integers = Set.of(30, 10, 12, 4);
List<Integer> result =
    integers.stream()
            .map(x -> x + 1)
            .collect(Collectors.toList());
```

Creating a Basic Stream from `Map`

- Creating a Stream from `Map`, call `entrySet`
- This will return a set of `Map.Entry` elements

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testBasicStreamFromMap

```
Map<String, String> countriesAndCapitals =
    Map.of("Denmark", "Copenhagen", "China", "Beijing");

List<String> result = countriesAndCapitals
    .entrySet()
    .stream()
    .map(e -> e.getKey() + "~" + e.getValue())
    .collect(Collectors.toList());
```

Results In:

```
[China~Beijing, Denmark~Copenhagen]
```

Creating a Basic Stream from an Array of Objects

- Creating a Basic Stream from an Array of Objects will yield a `Stream<T>`
- If they were primitive, they'd return a *Specialized Stream* for that type (see later)

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testBasicStreamFromArray

```
String[] stringArray = new String[]{"Foo", "Bar", "Baz", "Bam"};
Stream<String> stream = Arrays.stream(stringArray);
List<String> result =
    stream
          .map(x -> x + "!")
          .collect(Collectors.toList());
```

The return type ,*in this case*, from `Arrays.stream` is a `Stream<String>`

Specialized Streams

- Specific Stream for Primitives (e.g. `int`)
- There are a collection of primitive based `Stream` that support sequential and parallel aggregate operations.
- These operations are specialized for those primitives and they include
  - `IntStream`
    - To convert from a `Stream<Integer>` to a `IntStream` use `mapToInt`
    - To convert from a `IntStream` to a `Stream<Integer>` use `boxed()`
  - `DoubleStream`
    - To convert from a `Stream<Double>` to a `DoubleStream` use `mapToDouble`
    - To convert from a `DoubleStream` to a `Stream<Double>` use `boxed()`
  - `LongStream`
    - To convert from a `Stream<Long>` to a `LongStream` use `mapToLong`
    - To convert from a `LongStream` to a `Stream<Double>` use `boxed()`

Specialized `IntStream`

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testSpecializedIntStream

```
int result = IntStream.of(30, 12, 50).map(x -> x * 3).sum();
```

Specialized `LongStream`

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testSpecializedIntStream

```
long result = LongStream.of(30, 12, 50).map(x -> x * 3).sum();
```

Specialized `DoubleStream`

/src/test/java/com.xyzcorp.demos.streams.StreamsTest#testSpecializedDoubleStream

```
double result = DoubleStream.of(30, 12, 50).map(x -> x * 3).sum();
```

Creating a `Stream` from an Array of Primitives

Recall previously, the following returns a `Stream<String>`

```
String[] stringArray = new String[]{"Foo", "Bar", "Baz", "Bam"};
Stream<String> stream = Arrays.stream(stringArray);
```

But when dealing with primitives, the following returns an `IntStream`

```
int[] primitiveIntArray = new int[]{1, 3, 4, 5};
IntStream stream = Arrays.stream(primitiveIntArray);
```

Recall `IntStream` is specialized for integers

Creating Specialized Streams with `Builder`

- We can use `add` continually to add elements to builder
- Add as many elements
- Call `build` when done
- No calls for `add` are allowed after `build`

```
LongStream longStream =
    LongStream.builder().add(40L).add(10L).add(20L).build();
longStream
    .average()
    .ifPresentOrElse(avg -> System.out.printf("Average: %2.2f", avg),
        () -> System.out.println("No Average"));
```

Creating Specialized Streams with `Builder` and `accept`

- `add` offers the ability to chain calls
- `accept` returns `void` and operate one line at a time
- Use `build` when done
- No calls for `add` and `accept` are allowed after `build`

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testSpecializedLongStreamWithBuilderAndAccept

```
LongStream.Builder builder =
    LongStream.builder().add(40L).add(10L).add(20L);
builder.accept(31L);
builder.accept(41L);
builder.accept(51L);
builder.accept(61L);
LongStream longStream = builder.build();
String result =
    longStream
        .boxed()
        .map(String::valueOf)
        .collect(Collectors.joining(", "));
```

Specialized Streams have `range`

`range` is available in all Specialized Streams

src/main/java/com.xyzcorp.demos.streams.StreamsTest#testSpecializedIntStreamRange

```
int result = IntStream.range(0, 5).sum(); //10
```

`rangeClosed` is also available

src/main/java/com.xyzcorp.demos.streams.StreamsTest#testSpecializedLongStreamRangeClosed

```
long result = LongStream.rangeClosed(0, 5).sum(); //15
```

Converting

Converting from Specialized Streams to General Streams

- Use the method `mapToObj`
- Takes a primitive element and converts it to an `Object`

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testFromSpecializedStreamToGeneralStream

```
int[] primitiveIntArray = new int[]{1, 3, 4, 5};
IntStream stream = Arrays.stream(primitiveIntArray);
List<Integer> result =
    stream
          .map(x -> x + 1)
          .mapToObj(Integer::valueOf)
          .collect(Collectors.toList());
```

Converting from Specialized Streams to General Streams with `boxed`

- Offers the same functionality as `mapToObj`
- Cleaner alternative

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testFromSpecializedStreamToGeneralStreamWithBoxed

```
int[] primitiveIntArray = new int[]{1, 3, 4, 5};
List<Integer> result =
    Arrays.stream(primitiveIntArray)
          .map(x -> x + 1)
          .boxed()
          .collect(Collectors.toList());
```

Converting from General Streams to Specialized Streams

Java offers helpful methods to convert to Specialized Streams

- `mapToInt`
- `mapToLong`
- `mapToDouble`

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testFromGeneralStreamToSpecializedIntStream

```
Stream<Integer> integerStream = Stream.of(1, 2, 3, 4, 5);
IntStream intStream = integerStream.mapToInt(x -> x);
int result = intStream.sum();
```

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testFromGeneralStreamToSpecializedLongStream

```
Stream<Integer> integerStream = Stream.of(1, 2, 3, 4, 5);
LongStream longStream = integerStream.mapToLong(x -> x);
long result = longStream.sum();
```

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testFromGeneralStreamToSpecializedDoubleStream

```
Stream<Integer> integerStream = Stream.of(1, 2, 3, 4, 5);
DoubleStream doubleStream = integerStream.mapToDouble(x -> x);
double result = doubleStream.sum();
```

Intermediate Operators

Mapping a `Stream`

`map` applies a function to everything within a `Stream`

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testMap

```
List<Integer> result = Stream
   .of(1, 2, 3, 4)
   .map(x -> x * 2)
   .collect(Collectors.toList()); //List(2,4,6,8)
```

Filtering a `Stream`

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testFilter

```
List<Integer> result = Stream
  .of(1, 2, 3, 4)
  .filter(x -> x % 2 == 0)
  .collect(Collectors.toList());
```

FlatMapping a `Stream`

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testFlatMap

```
Stream<Integer> stream =
    Stream.of(1, 2, 3, 4)
          .flatMap(x -> Stream.of(-x, x, x + 2));
List<Integer> result =
    stream.collect(Collectors.toList());
```

Results in:

```
List.of(-1, 1, 3, -2, 2, 4, -3, 3, 5, -4, 4, 6);
```

`flatMap` as a Cleaner

- We will create a helper method, `safeCharAt`
  - If we can retrieve the `char` at index it will return `Optional.present`
  - Otherwise it will be `empty`

src/test/java/com.xyzcorp.demos.streams.StreamsTest#safeCharAt

```
private static Optional<Character> safeCharAt(String s, int index) {
    try {
        return Optional.of(s.charAt(index));
    } catch (java.lang.StringIndexOutOfBoundsException e) {
        return Optional.empty();
    }
}
```

- `Optional.stream`
  - Extremely useful
  - Is short for `o -> o.stream()` where `o` is an `Optional<T>`
    - `o.stream` will return Stream of the element inside the `Optional` if present
    - `empty` if the `Optional` is empty

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testFlatMapAsCleaner

```
var result =
  Stream.of("Apple", "Orange", "", "Banana", "Tomato", "Grapes", "")
        .map(s -> safeCharAt(s, 0))
        .flatMap(Optional::stream)
        .collect(Collectors.toList());
```

This returns:

```
List.of('A', 'O', 'B', 'T', 'G')
```

`peek` into your `Stream`

- `peek`
  - Accepts a `Consumer`
  - Provides an opportunity to perform a side effect
  - Typically, a log, or `System.out.println`

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testStreamWithPeek

```
List<Integer> result =
   Stream.of(1, 2, 3, 4, 5)
         .map(x -> x + 1)
         .peek(System.out::println)
         .filter(x -> x % 2 == 0)
         .collect(Collectors.toList());
```

Limiting the Number of Elements

- Returns a stream consisting of the elements of this stream
- Truncated to be no longer than maxSize in length.
- Particularly useful for *infinite* streams
- Optimized to only work on those number of elements

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testLimit

```
Stream<Integer> integerStream = Stream.iterate(0, x -> x + 1);
List<Integer> result =
    integerStream
        .map(x -> x + 4)
        .limit(10)
        .collect(Collectors.toList());
```

Skipping Elements

`skip` returns a stream consisting of the remaining elements of this stream after discarding the first `n` elements of the stream

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testSkip

```
List<Integer> result =
IntStream.range(0, 20).boxed().skip(10).collect(Collectors.toList());
```

Results In:

```
List.of(10, 11, 12, 13, 14, 15, 16, 17, 18, 19)
```

Filtering Distinct Elements

`distinct` returns a stream consisting of the distinct elements (according to `Object.equals(Object)`) of this stream

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testDistinct

```
List<String> distinct = Stream
   .of("Right", "Left", "Right", "Right")
   .distinct()
   .collect(Collectors.toList());
```

Results In:

```
["Left", "Right"]
```

Sorting a Stream

- `sorted` will use a `Comparator<T>` to determine how to sort a `Stream`
- The following example will sort by the length of the `String`

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testSortedWithComparator

```
List<String> list =
stream
    .sorted(new Comparator<String>() {
        @Override
        public int compare(String o1, String o2) {
            return Integer.compare(o1.length(), o2.length());
        }
    })
    .collect(Collectors.toList());
```

The result is:

```
List.of("Kiwi", "Apple", "Orange", "Banana", "Tomato", "Grapes");
```

`Comparator` methods

- `Comparator` has methods that aid in common tasks
  - Comparing common types: `int`, `double`
  - Multiple levels of comparision: first name then last name
  - Extracting certain fields from objects

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testSortedWithComparatorUtility

```
Stream<String> stream =
    Stream.of("Apple", "Orange", "Banana", "Tomato", "Grapes", "Kiwi");

List<String> list = stream
    .sorted(Comparator.comparingInt(String::length))
    .collect(Collectors.toList());
```

Advanced editors often help with suggestions

Identity Function Defined

$$f(x) = x$$

Identity Function Definition

> In mathematics, an identity function, also called an identity relation or identity map or identity transformation, is a function that always returns the same value that was used as its argument.

Source: Wikipedia

Inside of `java.util.Function`

```
static <T> Function<T, T> identity() {
        return t -> t;
}
```

Combination Comparators

`thenComparing` offers possibility to chained comparisons

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testSortedWithNestedComparators

```
Stream<String> stream =
    Stream.of("Apple", "Orange", "Banana", "Tomato", "Grapes", "Plum"
        , "Kiwi");
System.out.println(stream
    .sorted(Comparator
        .comparing(String::length)
        .thenComparing(x -> x))
    .collect(Collectors.toList()));
```

Using the Identity Function:

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testSortedWithNestedComparators

```
Stream<String> stream =
    Stream.of("Apple", "Orange", "Banana", "Tomato", "Grapes", "Plum"
        , "Kiwi");
System.out.println(stream
    .sorted(Comparator
        .comparing(String::length)
        .thenComparing(Function.identity()))
    .collect(Collectors.toList()));
```

Terminal Operators

Counting Elements

- Terminal operation
- Counts the number of elements in `Stream`
- Supported in both general and specialized streams

/src/test/java/com.xyzcorp.demos.streams.StreamsTest#testGeneralStreamCount

```
long count = Stream.of(12, 4, 10).count();
```

/src/test/java/com.xyzcorp.demos.streams.StreamsTest#testSpecializedStreamCount

```
long count = Stream.of(12, 4, 10).count();
```

Reducing without a `seed`

- Terminal Operation
- Reduction iteratively calls a BiFunction to calculate the next iteration
- Continues until exhausted
- Returns an `Optional` in case it received an empty `Stream`

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testReduceWithoutASeed

```
Stream<Integer> stream = Stream.of(1, 2, 3, 4, 5, 6);
Optional<Integer> reduction = stream.reduce((total, next) -> {
    System.out.format("total: %d, next: %d\n", total, next);
    return total + next;
});
```

The `System.out.println` renders:

```
total: 1, next: 2
total: 3, next: 3
total: 6, next: 4
total: 10, next: 5
total: 15, next: 6
```

The result is:

```
Optional.of(21);
```

Reduce with a seed

- Reduction has a seed
- This means that it always has an answer

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testReduceWithASeed

```
Stream<Integer> stream = Stream.of(1, 2, 3, 4, 5, 6);
Integer reduction = stream.reduce(0, (total, next) -> {
    System.out.format("total: %d, next: %d\n", total, next);
    return total + next;
});
```

The `System.out.println` renders:

```
total: 1, next: 2
total: 3, next: 3
total: 6, next: 4
total: 10, next: 5
total: 15, next: 6
```

The result is:

```
21
```

The above answer is not an `Optional`

Finding the First Element

- `findFirst` returns the first element of a `Stream`
- Returns an `Optional<E>`

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testFindFirstSuccessful

```
Optional<Integer> first = Stream.of(1, 2, 4, 5).findFirst();
```

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testFindFirstUnSuccessful

```
Optional<Integer> first = Stream.<Integer>empty().findFirst();
```

Specialized Streams Terminal Operations

The major benefit for a specialized stream, like `IntStream` are the terminal operations

- `average`
- `sum`
- `summaryStatistics`
- `max`
- `min`

Sample of `summaryStatistics`

src/test/com.xyzcorp.demos.streams.StreamsTest#testSummaryStatistics

```
IntStream intStream = IntStream.of(12, 19, 40, 60, 100, 200, 15, 0, 3);
System.out.println(intStream.summaryStatistics());
```

Results in:

```
IntSummaryStatistics{count=9, sum=449, min=0, average=49.888889, max=
200}
```

Infinite Streams

`iterate`

- Returns an infinite sequential ordered Stream produced by iterative application of a function `f`
- First applies to an initial element seed, producing a Stream consisting of `seed`, `f(seed)`, `f(f(seed))`
- The first element (position 0) in the `Stream` will be the provided `seed`
- For $n > 0$, the element at position `n`, will be the result of applying the function `f` to the element at position `n - 1`

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testIterate

```
Stream<Integer> iterate = Stream.iterate(0,
            integer -> integer + 3);
List<Integer> result = iterate.limit(5).collect(Collectors.toList());
```

Results In:

```
[0, 3, 6, 9, 12]
```

`iterate` with a `Predicate`

- Iterate can also have a predicate as a condition for the next element
- The resulting sequence may be empty if the `hasNext` predicate does not hold on the seed value
- The stream will continue until the `Predicate` dictates that it should terminate
- Use Case: Custom ranges

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testIterateWithPredicate

```
List<Integer> result =
   Stream
      .iterate(0, x -> x <= 5, integer -> integer + 1)
      .collect(Collectors.toList());
```

Results In:

```
[0, 1, 2, 3, 4, 5]
```

`generate`

- `generate` lazily invokes a function when it requires the next element
- Suitable for constant streams

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testGenerate

```
List<LocalDateTime> result =
            Stream.generate(LocalDateTime::now)
                  .flatMap(x -> Stream.of(x, x.plusYears(10)))
                  .limit(5)
                  .collect(Collectors.toList());
```

Results In:

```
[2017-11-06T12:52:04.499934, 2027-11-06T12:52:04.499934,
 2017-11-06T12:52:04.508439, 2027-11-06T12:52:04.508439,
 2017-11-06T12:52:04.508490]
```

Common Collectors

Grouping

- Returns a `Collector` implementing a "group by" operation on input elements of type T
- Grouping elements according to a classification function, and returning the results in a `Map`

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testGroupingBy

```
IntStream stream = IntStream.range(0, 10);
Map<Boolean, List<Integer>> groups =
    stream.boxed()
          .collect(Collectors.groupingBy(i -> i % 2 == 0));
```

The result is:

```
{false=[1, 3, 5, 7, 9], true=[0, 2, 4, 6, 8]}
```

Partitioning

- Returns a `Collector` which partitions the input elements according to a `Predicate`
- Organizes them into a `Map<Boolean, List<T>>`
- The returned Map always contains mappings for both `false` and `true` keys.

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testPartitioning

```
Stream<String> stream =
    Stream.of("Apple", "Orange", "Banana", "Tomato", "Grapes");
Map<Boolean, List<String>> partition = stream.collect
    (Collectors.partitioningBy(s -> "AEIOU"
        .indexOf(s.toUpperCase().charAt(0)) >= 0));
```

The result is:

```
{false=[Banana, Tomato, Grapes], true=[Apple, Orange]}
```

Joining

- Returns a Collector that concatenates the input elements
- Separated by the specified delimiter
- With the specified prefix and suffix, in encounter order
- Elements must be a subtype of `CharSequence`

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testJoining

```
Stream<String> stream =
    Stream.of("Apple", "Orange", "Banana", "Tomato", "Grapes");
String result = stream.collect(Collectors.joining(", ", "{", "}"));
```

The result is:

```
{Apple, Orange, Banana, Tomato, Grapes}
```

`toMap`

- Just like you can create a `List` or `Set` as collector.
- You can also create a `Map` using `toMap`
- Keys and values are the result of applying the provided mapping functions to the input elements

Given a setup of objects like an `Order` and `OrderItem` relationship:

/src/main/java/com.xyzcorp.demos.streams.Order

```
public class Order {
    private final String firstName;
    private final String lastName;
    private final String city;
    private final String state;
    private final List<OrderItem> orderItems;
}
```

/src/main/java/com.xyzcorp.demos.streams.OrderItem

```
public class OrderItem {
    private final int quantity;
    private final Product product;
    private final Order order;
}
```

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testToMap

```
Map<String, Integer> result = orders
   .stream()
   .collect(Collectors
       .toMap(Order::getFirstName,
           o -> o.getOrderItems()
                 .stream()
                 .mapToInt(OrderItem::getQuantity).sum()));
```

There is a distinct difference between `toMap` and `groupingBy`. `toMap` is intended to hold the same number of entries as the `Stream`. `groupingBy` is intended as an aggregation.

Custom Collectors

When calling `collect`, you can specify your own functions

Java API for the `Stream` method `collect`:

```
<R> R collect(Supplier<R> supplier,
              BiConsumer<R, ? super T> accumulator,
              BiConsumer<R, R> combiner);
```

The `Supplier` in `collect`

- `Function` that creates a new result container.
- In a parallel execution:

- May be called multiple times
- Must return a fresh value each time.

Java API for the `Stream` method `collect`:

```
<R> R collect(Supplier<R> supplier,
              BiConsumer<R, ? super T> accumulator,
              BiConsumer<R, R> combiner);
```

The `Accumulator` in `collect`

- `Function` for incorporating an additional element into a result

Java API for the `Stream` method `collect`:

```
<R> R collect(Supplier<R> supplier,
              BiConsumer<R, ? super T> accumulator,
              BiConsumer<R, R> combiner);
```

The `Combiner` in `collect`

- `Function` for combining two values
- Must be compatible with the `accumulator` function

Java API for the `Stream` method `collect`:

```
<R> R collect(Supplier<R> supplier,
              BiConsumer<R, ? super T> accumulator,
              BiConsumer<R, R> combiner);
```

Create your own `collect`

- The complete custom `collect`:
  - `Supplier` for the initial element
  - `BiConsumer` for how to bring in individual elements
  - `BiConsumer` for how to bring in different collections

```
@Test
public void testCompleteCollector() {
   List<Integer> numbers = Arrays.asList(0, 1, 2, 3, 4, 5, 6, 7, 8, 9);
   List<Integer> result = numbers.stream()
                           .map(x -> x + 1)
                           .collect(
   new Supplier<List<Integer>>() {
       @Override
       public List<Integer> get() {
           return new ArrayList<Integer>();
       }
   }, new BiConsumer<List<Integer>, Integer>() {
       @Override
       public void accept(List<Integer> integers, Integer integer) {
           integers.add(integer);
       }
   }, new BiConsumer<List<Integer>, List<Integer>>() {
       @Override
       public void accept(List<Integer> left, List<Integer> right) {
          left.addAll(right);
       }
   });
   System.out.println("Ending with the result = " + result);
}
```

Converting `collect` with Lambdas

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testBasicCustomCollector

```
List<Integer> numbers = Arrays.asList(0, 1, 2, 3, 4, 5, 6, 7, 8, 9);
List<Integer> result =
    numbers.stream()
           .map(x -> x + 1)
           .collect(ArrayList::new, ArrayList::add, ArrayList::addAll);
System.out.println("Ending with the result = " + result);
```

Parallelizing Streams

- We can call `parallel()` anywhere in our pipeline when needed.
- This is will cause the rest of that pipeline to be executed on a different thread.
- Aggregate operations and parallel streams enable you to implement parallelism with non-thread-safe collections, provided that you ***do not modify the collection*** while you are operating on it.
- Parallelism is not automatically faster than performing operations serially, although it can be if you have enough data and processor cores

Using `parallel` in Streams

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testParallelCollections

```
List<Integer> collect =
    IntStream.range(0, 10)
             .boxed()
             .parallel()
             .map(x -> x + 1)
             .peek(x-> System.out.println("parallel:" + Thread
.currentThread().getName()))
             .collect(Collectors.toList());
System.out.println(collect);
```

Grouping Concurrently

- Returns a concurrent Collector implementing a "group by" operation on input elements of type `T`
- Groups elements according to a classification function.
- This is a concurrent and unordered Collector.
- The classification function maps elements to some key type `K`
- The collector produces a `ConcurrentMap<K, List<T>>` whose keys are the values resulting from applying the classification function to the input elements, and whose corresponding values are Lists containing the input elements which map to the associated key under the classification function.
- There are no guarantees on the type, mutability, or serializability of the ConcurrentMap or List objects returned, or of the thread-safety of the List objects returned.

src/test/java/com.xyzcorp.demos.streams.StreamsTest#testGroupingByConcurrent

```
IntStream stream = IntStream.range(0, 10);
Map<Boolean, List<Integer>> groups =
    stream.parallel()
          .boxed()
          .collect(Collectors.groupingByConcurrent(i -> i % 3 == 0));
System.out.println(groups);
```

Results In:

```
{false=[1, 2, 8, 7, 4, 5], true=[0, 9, 3, 6]}
```

The above result is a `java.util.concurrent.ConcurrentHashMap`

Lab: Streams

Step 1: Open *src/test/java/com.xycorp.exercises.streams.StreamsExercises*

Step 2: In the test `testConvertIntegerListToHexidecimal`, initialize `Arrays.asList(1,50,100,200,921)` and convert that list to a `List` of hexadecimals. Research how to convert an `Integer` to hexadecimal. *Do not use* `while` *or* `for` *loops or any old style iteration.*

Step 3: In the test `testConvertIntegerListToDouble`, initialize `Arrays.asList(1,50,100,200,921)` and convert that list to a `List` of `Double`. *Do not use* `while` *or* `for` *loops or any old style iteration.*

Step 4: In the test `testFactorialUsingStreams`, test a class that you create that will calculate the factorial of a number. *Do not use* `while` *or* `for` *loops or any old style iteration.*

Step 5: In the test `testFindTopFiveEmployees`, concatenate two `Streams` that read from `jkRowlingEmployees` and `georgeLucasEmployees`, sort the combined streams by `salary` in descending order, find the top five, collect them as a string with a new line. *Do not use* `while` *or* `for` *loops or any old style iteration.*

Step 6: In the test `testAllEmployeesSalaryWithManager`, give the reference `managers` only, find the sum of all the employees and the managers. **You can only use the `managers` reference**. *Do not use* `while` *or* `for` *loops or any old style iteration.*

Step 7: Which managers employees are paid more? J.K. Rowling or George Lucas? In `testWhichManagersEmployeesArePaidMore` find out. *Do not use* `while` *or* `for` *loops or any old style iteration.*

Step 8: In `testCreateAMapOfEmployeeKeyWithManagerValue` create a Map where the keys are all the employees (non-managers) and the values are their managers *Do not use* `while` *or* `for` *loops or any old style iteration.*

Java Date Time API

ISO 8601 Standard

- Standard and Collaborative means of managing date and time
- Based on the cesium-133 atom atomic clock

ISO 8601 Formats

Format	Example
Date	2014-01-01
Combined Date and Time in UTC	2014-07-07T07:01Z
Combined Date and Time in MDT	2014-07-07T07:38:51.716-06:00
Date With Week Number	2014-W27-3
Ordinal Date	2014-188
Duration	P3Y6M4DT12H30M5S
Finite Interval	2014-03-01T13:00:00Z/2015-05-11T15:30:00Z
Finite Start with Duration	2014-03-01T13:00:00Z/P1Y2M10DT2H30M
Duration with with Finite End	P1Y2M10DT2H30M/2015-05-11T15:30:00Z

`java.util.Date`

- Introduced millisecond resolution
- java.util.Date
- What was wrong with it?
  - Constructors that accept year arguments require offsets from 1900, which has been a source of bugs.
  - January is represented by 0 instead of 1, also a source of bugs.
  - Date doesn't describe a date but describes a date-time combination.
  - Date's mutability makes it unsafe to use in multithreaded scenarios without external synchronization.
  - Date isn't amenable to internationalization.

Source: http://www.javaworld.com/article/2078757/java-se/java-101-the-next-generation-it-s-time-for-a-change.html

`java.util.Calendar`

- Introduced in Java 1.1
- What is wrong with it?

- It isn't possible to format a calendar.
- January is represented by 0 instead of 1, a source of bugs.
- Calendar isn't type-safe; for example, you must pass an int-based constant to the get(int field) method. (In fairness, enums weren't available when Calendar was released.)
- Calendar's mutability makes it unsafe to use in multithreaded scenarios without external synchronization. (The companion java.util.TimeZone and java.text.DateFormat classes share this problem.)
- Calendar stores its state internally in two different ways — as a millisecond offset from the epoch and as a set of fields — resulting in many bugs and performance issues.

Source: http://www.javaworld.com/article/2078757/java-se/java-101-the-next-generation-it-s-time-for-a-change.html

Terrible Readability of `java.util.Calendar`

```
> new java.util.GregorianCalendar

java.util.GregorianCalendar = java.util.GregorianCalendar[time
=1393764079082,areFieldsSet=true,areAllFieldsSet=true,lenient=true,zone=
sun.util.calendar.ZoneInfo[id="America/New_York",offset=-18000000
,dstSaving=3600000,useDaylight=true,transitions=235,lastRule=java.util.S
impleTimeZone[id=America/New_York,offset=-18000000,dstSaving=3600000
,useDaylight=true,startYear=0,startMode=3,startMonth=2,startDay=8,startD
ayOfWeek=1,startTime=7200000,startTimeMode=0,endMode=3,endMonth=10,endDa
y=1,endDayOfWeek=1,endTime=7200000,endTimeMode=0]],firstDayOfWeek=1,mini
malDaysInFirstWeek=1,ERA=1,YEAR=2014,MONTH=2,WEEK_OF_YEAR=10,WEEK_OF_MON
TH=2,DAY_OF_MONTH=2,DAY_OF_YEAR=61,DAY_OF_WEEK=1,DAY_OF_WEEK_IN_MONTH=1,
AM_PM=0,HOUR=7,HOUR_OF_DAY=7,MINUTE=41,SECOND=19,MILLISECOND=82,ZONE_OFF
SET=-18000000,DST_...
```

What was cool about Joda Time?

- Straight-forward instantiation and methods
- UTC/ISO 8601 Based, not Gregorian Calendar
- Has support for other calendar systems if you need it (Julian, Gregorian-Julian, Coptic, Buddhist)
- Includes classes for date times, dates without times, times without dates, intervals and time periods.
- Advanced formatting
- Well documented and well tested
- Immutable!
- Months are 1 based

About the Java 8 Date Time API

- Authored by the same team as Joda Time
- Immutable & Threadsafe
- Learned from previous mistakes made in Joda Time
- There are no *constructors* (Dude what?)
- Nanosecond Resolution

The Java Date Time Packaging

- `java.time` - Base package for managing date time
- `java.time.chrono` - Package that handles alternative calendering and chronology systems
- `java.time.format` - Package that handles formatting of dates and times
- `java.time.temporal` - Package that allows us to query dates and times

Date Time Conventions

- `of` - static factory usually validating input parameters not converting them
- `from` - static factory that converts to an instance of a target class
- `parse` - static factory that parses an input string
- `format` - uses a specified formatter to format the date
- `get` - Returns part of the state of the target object
- `is` - Queries the state of the object
- `with` - Returns a copy of the object with one element changed, this is the immutable equivalent
- `plus` - Returns a copy of the target object with the amount of time added
- `minus` - Returns a copy of the target object with the amount of time subtracted
- `to` - Converts this object to another object type
- `at` - Combines the object with another

`Instant`

- Single point in time
- Time since the Unix/Java Epoch `1970-01-01T00:00:00Z`
- Differs from the `java.util.Date` and `long` representation
- Contains two states:
  - `long` of seconds since the Unix Epoch
  - `int` of nano seconds within one second

`Instant` Resolution!

An `Instant` can be resolved as 1.844674407x10[19] seconds or 584542046090 years!

`Instant` Exemplified

/src/test/java/com.xyzcorp.demos.datetime.DatesTest#testInstant

```
Instant instant = Instant.now();
System.out.println("instant = " + instant);
System.out.println(instant.getEpochSecond());
System.out.println(instant.getNano());
```

`Enum`

`Month` and `DayOfWeek`

- The Java Date/Time API contains `enum` classes to describe our months and days
  - `Month`
  - `DayOfWeek`

`Month` and `DayOfWeek`

```
DayOfWeek.SUNDAY
DayOfWeek.FRIDAY
```

```
Month.JANUARY
Month.JULY
Month.DECEMBER
```

`ChronoUnit`

- `enum` to represent a unit of time for a scalar
- `implements TemporalUnit`
- `ChronoUnit` is meant to be general enough for various calendars

`ChronoUnit` Exemplified

```
ChronoUnit.DAYS
ChronoUnit.CENTURIES
ChronoUnit.ERAS
ChronoUnit.MINUTES
ChronoUnit.MONTHS
ChronoUnit.SECONDS
ChronoUnit.FOREVER
```

Adding `ChronoUnit` to `Instant`

src/test/java/com.xyzcorp.demos.datetime.DatesTest#testChronoUnitAddToInstant

```
Instant.now().plus(19, ChronoUnit.DAYS)
```

`ChronoUnit` to Determine Time Between

src/test/java/com.xyzcorp.demos.datetime.DatesTest#testChronoUnitBetween

```
long between = ChronoUnit.DAYS.between
    (Instant.parse("2019-01-05T12:00:00.0Z"),
        Instant.parse("2019-01-01T12:00:00.0Z"));
System.out.println("between = " + between);
```

The above uses `parse` to parse an ISO-8601 formatted `String`

`ChronoField`

- Represents a field in a date
- Given: `2010-10-22T12:00:13` has six fields
  - The year: `2010`
  - The month: `10`
  - The day of the month: `22`
  - The hour of the day: `12`
  - The minute: `0`
  - The seconds: `13`
- `implements TemporalField`
- `ChronoField` is also meant to be general enough for various calendars

`ChronoField` Exemplified

```
ChronoField.MONTH_OF_YEAR
ChronoField.DAY_OF_MONTH
ChronoField.HOUR_OF_DAY
ChronoField.SECOND_OF_MINUTE
ChronoField.SECOND_OF_DAY
ChronoField.MINUTE_OF_DAY
ChronoField.MINUTE_OF_HOUR
```

src/test/java/com.xyzcorp.demos.datetime.DatesTest#testChronoField

```
Instant.now.get(ChronoField.HOUR_OF_DAY);
```

Local Dates and Times

- `LocalDate` - An ISO 8601 date representation without timezone and time
- `LocalTime`- An ISO 8601 time representation without timezone and date
- `LocalDateTime` - An ISO 8601 date and time representation without time zone

Creating a `LocalDate`

```
LocalDate february20th = LocalDate.of(2014, Month.FEBRUARY, 20);
System.out.println(february20th);
```

Creating a `LocalTime`

```
LocalTime.MIDNIGHT;
LocalTime.NOON;
LocalTime.of(23, 12, 30, 500);
LocalTime.now();
LocalTime.ofSecondOfDay(11 * 60 * 60);
LocalTime.from(LocalTime.MIDNIGHT.plusHours(4));
```

Creating a `LocalDateTime`

```
LocalDateTime.of(2014, 2, 15, 12, 30, 50, 200);
LocalDateTime.now();
LocalDateTime.from(
   LocalDateTime.of
      (2014, 2, 15, 12, 30, 40, 500)
        .plusHours(19)));
LocalDateTime.MIN;
LocalDateTime.MAX;
```

ZonedDateTime

- Specifies a complete date and time in a particular time zone
- Contains methods that can convert from `LocalDate`, `LocalTime`, and `LocalDateTime` to `ZonedDateTime`

But first, `ZoneId`

- `ZoneId` represents the IANA Time Zone Entry
- http://www.iana.org/time-zones
- Download tar.gz file, locate the region file (e.g. northamerica)
- TimeZone names are divided by region

```
# Monaco
# Shanks & Pottenger give 0:09:20 for Paris Mean Time; go with Howse's
# more precise 0:09:21.
# Zone  NAME        GMTOFF  RULES   FORMAT  [UNTIL]
Zone    Europe/Monaco   0:29:32 -   LMT 1891 Mar 15
            0:09:21 -   PMT 1911 Mar 11    # Paris Mean Time
            0:00    France  WE%sT   1945 Sep 16 3:00
            1:00    France  CE%sT   1977
            1:00    EU  CE%sT
```

Creating the `ZoneId`

```
ZoneId.of("America/Denver");
ZoneId.of("Asia/Jakarta");
ZoneId.of("America/Los_Angeles");
ZoneId.ofOffset("UTC", ZoneOffset.ofHours(-6));
```

`ZonedDateTime` exemplified

```
ZonedDateTime.now();  //Current Date Time with Zone

ZonedDateTime myZonedDateTime = ZonedDateTime.of(2014, 1, 31, 11, 20,
30, 93020122, ZoneId.systemDefault());

ZonedDateTime nowInAthens = ZonedDateTime.now(ZoneId.of(
"Europe/Athens"));

LocalDate localDate = LocalDate.of(2013, 11, 12);
LocalTime localTime = LocalTime.of(23, 10, 44, 12882);
ZoneId chicago = ZoneId.of("America/Chicago");
ZonedDateTime chicagoTime = ZonedDateTime.of(localDate, localTime,
chicago);

LocalDateTime localDateTime = LocalDateTime.of(1982, Month.APRIL, 17,
14, 11);
ZonedDateTime jakartaTime = ZonedDateTime.of(localDateTime, ZoneId.of
("Asia/Jakarta"));
```

Daylight Saving Time Begins

- In the summer
  - In the case of a gap, when clocks jump forward, there is no valid offset.
  - Local date-time is adjusted to be later by the length of the gap
  - For a typical one hour daylight savings change, the local date-time will be moved one hour later into the offset typically corresponding to "summer"

Daylight Saving Time using Java Date Time API

```
LocalDateTime date = LocalDateTime.of(2012, 11, 12, 13, 11, 12);
date.atZone(ZoneId.of("America/Los_Angeles")) //2012-11-12T13:11:12-
08:00[America/Los_Angeles]

LocalDateTime daylightSavingTime = LocalDateTime.of(2014, 3, 9, 2, 0, 0,
0);
daylightSavingTime.atZone(ZoneId.of("America/Denver")); //2014-03-
09T03:00-06:00[America/Denver]

LocalDateTime daylightSavingTime2 = LocalDateTime.of(2014, 3, 9, 2, 30,
0, 0);
daylightSavingTime2.atZone(ZoneId.of("America/New_York")); //2014-03-
09T03:30-04:00[America/New_York]

LocalDateTime daylightSavingTime3 = LocalDateTime.of(2014, 3, 9, 2, 0,
0, 0);
daylightSavingTime3.atZone(ZoneId.of("America/Phoenix")); //2014-03-
09T02:00-07:00[America/Phoenix]

LocalDateTime daylightSavingTime4 = LocalDateTime.of(2014, 3, 9, 2, 59,
59, 999999999);
daylightSavingTime4.atZone(ZoneId.of("America/Chicago")); //2014-03-
09T03:59:59.999999999-05:00[America/Chicago]
```

Daylight Saving Time using the Java Date Time API

- In the winter
  - In the case of an overlap, when clocks are set back, there are two valid offsets.
  - This method uses the earlier offset typically corresponding to "summer".

Standard Time using the Java Date Time API

```
LocalDateTime date2 = LocalDateTime.of(2012, 11, 12, 13, 11, 12);
date2.atZone(ZoneId.of("America/Los_Angeles"))); //2012-11-12T13:11:12-
08:00[America/Los_Angeles]

LocalDateTime standardTime = LocalDateTime.of(2014, 11, 2, 2, 0, 0, 0);
standardTime.atZone(ZoneId.of("America/Denver")); //2014-11-02T02:00-
07:00[America/Denver]

LocalDateTime standardTime2 = LocalDateTime.of(2014, 11, 2, 2, 30, 0,
0);
standardTime2.atZone(ZoneId.of("America/New_York")); //2014-11-02T02:30-
05:00[America/New_York]

LocalDateTime standardTime3 = LocalDateTime.of(2014, 11, 2, 2, 0, 0, 0);
standardTime3.atZone(ZoneId.of("America/Phoenix")); //2014-11-02T02:00-
07:00[America/Phoenix]

LocalDateTime standardTime4 = LocalDateTime.of(2014, 11, 2, 2, 59, 59,
999999999);
standardTime4.atZone(ZoneId.of("America/Chicago")); //2014-11-
02T02:59:59.999999999-06:00[America/Chicago]
```

Which 1:30 AM?

```
LocalDateTime standardTime6 = LocalDateTime.of(2014, 11, 2, 1, 30, 0,
0);
standardTime6.atZone(ZoneId.of("America/New_York")));
standardTime6.atZone(ZoneId.of("America/New_York"))
        .withEarlierOffsetAtOverlap().toInstant().getEpochSecond());
standardTime6.atZone(ZoneId.of("America/New_York"))
        .withLaterOffsetAtOverlap().toInstant().getEpochSecond());
```

Shifting Time

`Duration` and `Period`

- To model a span of time (e.g. 10 days) you have two choices
  - `Duration` - a span of time in seconds and nanoseconds
  - `Period` -a span of time in years, months and days
- Both implement `TemporalAmount`

`Duration`

- Spans only seconds and nanoseconds
- Meant to adjust `LocalTime` (assumes no dates are involved)

- `static` method calls include construction for:
  - days
  - hours
  - milliseconds
  - nanoseconds
- Can have a side effect depending on which API calls you make

`Duration` Exemplified

```
Duration duration =  Duration.ofDays(33); //seconds or nanos
Duration duration1 = Duration.ofHours(33); //seconds or nanos
Duration duration2 = Duration.ofMillis(33); //seconds or nanos
Duration duration3 = Duration.ofMinutes(33); //seconds or nanos
Duration duration4 = Duration.ofNanos(33); //seconds or nanos
Duration duration5 = Duration.ofSeconds(33); //seconds or nanos
Duration duration6 = Duration.between(LocalDate.of(2012, 11, 11),
LocalDate.of(2013, 1, 1));
```

`Period`

- Spans years, months, weeks and days
- Meant to adjust `LocalDate` (assumes no times are involved)
- `static` method calls include construction for:
  - days
  - months
  - weeks
  - years
- Can also have a side effect depending on which API call you make

`Period` Exemplified

```
Period p = Period.ofDays(30);
Period p1 = Period.ofMonths(12);
Period p2 = Period.ofWeeks(11);
Period p3 = Period.ofYears(50);
```

Shifting Dates and Time

- Any class that derives from `Temporal` has the ability to add or remove any time using methods:
  - `plus`
  - `minus`

- Changing any one implementation of a `Temporal` will provide a copy!

Shifting `LocalDate`

- A shift of `LocalDate` can be done with:
  - a `TemporalAmount` (`Period`)
  - a `long` with `TemporalUnit` (`ChronoUnit`)

```
LocalDate localDate = LocalDate.of(2012, 11, 23);
localDate.plus(3, ChronoUnit.DAYS); //2012-11-26
localDate.plus(Period.ofDays(3)); //2012-11-26
try {
   localDate.plus(Duration.ofDays(3));  //2012-11-26
} catch (UnsupportedTemporalTypeException e) {
   e.printStackTrace();
}
```

Shifting `LocalTime`

- A shift of `LocalTime` can be done with:
  - a `TemporalAmount` (`Duration`)
  - a `long` with `TemporalUnit` (`ChronoUnit`)

```
LocalTime localTime = LocalTime.of(11, 20, 50);
localTime.plus(3, ChronoUnit.HOURS); //14:20:50
localTime.plus(Duration.ofDays(3)); //11:20:50
try {
  localTime.plus(Period.ofDays(3));
} catch (UnsupportedTemporalTypeException e) {
  e.printStackTrace();
}
```

Temporal Adjusters

- New construct
- `interface` that can be implemented to specialize a time shift
- Use Case - An object that shifts time based on external factors

```
@FunctionalInterface
public interface TemporalAdjuster {
   Temporal adjustInto(Temporal temporal);
}
```

Overly Simplified Temporal Adjuster

```
TemporalAdjuster fourMinutesFromNow = new TemporalAdjuster() {
   @Override
   public Temporal adjustInto(Temporal temporal) {
       return temporal.plus(4, ChronoUnit.MINUTES);
   }
};

LocalTime localTime = LocalTime.of(12, 0, 0);
localTime.with(fourMinutesFromNow)); //12:04
```

Lambda Capable `TemporalAdjuster`

Remember this?

```
@FunctionalInterface
public interface TemporalAdjuster {
      Temporal adjustInto(Temporal temporal);
}
```

That's a Java 8 Lambda! Therefore `fourMinutesFromNow` can now be:

```
TemporalAdjuster fourMinutesFromNow = temporal -> temporal.plus(4,
ChronoUnit.MINUTES);
LocalTime localTime = LocalTime.of(12, 0, 0);
localTime.with(fourMinutesFromNow)); //12:04
```

Refactoring and inlining

```
LocalTime.of(12, 0, 0).with(temporal -> temporal.plus(4, ChronoUnit
.MINUTES));
```

Parsing and Formatting

- Converting dates and times from a `String` is always important
- `java.time.format.DateFormatter`
- Immutable and Threadsafe

Formatting `LocalDate`

```
DateTimeFormatter dateFormatter = DateTimeFormatter.ofLocalizedDate
(FormatStyle.MEDIUM);
dateFormatter.format(LocalDate.now()); // Jan. 19, 2014
```

Formatting `LocalTime`

```
DateTimeFormatter timeFormatter =
   DateTimeFormatter.ofLocalizedTime(FormatStyle.MEDIUM);

timeFormatter.format(LocalTime.now()); //3:01:48 PM
```

Formatting `LocalDateTime`

```
DateTimeFormatter dateTimeFormatter =
   DateTimeFormatter.ofLocalizedDateTime(FormatStyle.MEDIUM,
FormatStyle.SHORT);

dateTimeFormatter.format(LocalDateTime.now()); // Jan. 19, 2014 3:01 PM
```

Formatting Customized Patterns

```
DateTimeFormatter obscurePattern =
   DateTimeFormatter.ofPattern("MMMM dd, yyyy '(In Time Zone: 'VV')'");
ZonedDateTime zonedNow = ZonedDateTime.now();

obscurePattern.format(zonedNow); //January 19, 2014 (In Time Zone:
America/Denver)
```

Formatting with Localization

- Localization using `java.util.Locale` is available for:
  - `ofLocalizedDate`
  - `ofLocalizedTime`
  - `ofLocalizedDateTime`

```
ZonedDateTime zonedDateTime = ZonedDateTime.now(ZoneId.of(
"Europe/Paris"));

DateTimeFormatter longDateTimeFormatter =
DateTimeFormatter.ofLocalizedDateTime(FormatStyle.FULL, FormatStyle.
FULL).withLocale(Locale.FRENCH);
longDateTimeFormatter.getLocale(); //fr
longDateTimeFormatter.format(zonedDateTime); //samedi 19 janvier 2014 00
h 00 CET
```

Shifting Time Zones

```
LocalDateTime localDateTime = LocalDateTime.of(1982, Month.APRIL, 17,
14, 11);
ZonedDateTime jakartaTime = ZonedDateTime.of(localDateTime, ZoneId.of
("Asia/Jakarta"));
jakartaTime.withZoneSameInstant(ZoneId.of("America/Los_Angeles")));
//1982-04-16T23:11-08:00[America/Los_Angeles]
jakartaTime.withZoneSameLocal(ZoneId.of("America/New_York"))); //1982-
04-17T14:11-05:00[America/New_York]
```

Temporal Querying

- Process of asking information about a `TemporalAccessor`
  - `LocalDate`
  - `LocalTime`
  - `LocalDateTime`
  - `ZonedDateTime`

```
@FunctionalInterface
public interface TemporalQuery<R> {
    R queryFrom(TemporalAccessor temporal);
}
```

A Festive Example

```
@Test
public void testDaysBeforeChristmas() {
    TemporalQuery<Long> daysBeforeChristmas = temporal -> {
        LocalDate localDate = LocalDate.from(temporal);
        long d = ChronoUnit.DAYS.between(localDate,
                LocalDate.of(localDate.getYear(), 12, 25));
        if (d >= 0) return d;
        return ChronoUnit.DAYS.between
                (localDate, LocalDate.of(localDate.getYear() + 1, 12,
25));
    };

    System.out.println(LocalDate.of(2013, 12, 26).query
(daysBeforeChristmas)); //364
}
```

Simple Parsing Example

```
DateTimeFormatter dateFormatter = DateTimeFormatter.ofLocalizedDate
(FormatStyle.MEDIUM);
dateFormatter.parse("Jan 19, 2014")); // {}, ISO resolved to 2014-01-19
```

- Parses to `java.time.format.Parsed` which is rather useless
- The more effective call is to `parse(CharSequence, TemporalQuery)`

First Attempt

```
TemporalQuery<LocalDate> localDateTemporalQuery = new TemporalQuery
<LocalDate>() {
   @Override
   public LocalDate queryFrom(TemporalAccessor temporal) {
       return LocalDate.from(temporal);
   }
};

dateFormatter.parse("Jan 19, 2014", localDateTemporalQuery); //2014-01-
19
```

Second Attempt

```
dateFormatter.parse("Jan 19, 2014", temporal -> LocalDate.from(
temporal)); //2014-01-19
```

Last attempt

```
dateFormatter.parse("Jan 19, 2014", LocalDate::from); // Jan 19, 2014
```

Interoperabilility with Legacy Code

- `calendar.toInstant()` - converts the Calendar object to an Instant.
- `gregorianCalendar.toZonedDateTime()` - converts a GregorianCalendar instance to a ZonedDateTime.
- `gregorianCalendar.from(ZonedDateTime)` - creates a GregorianCalendar object using the default locale from a ZonedDateTime instance.
- `date.from(Instant)` - creates a Date object from an Instant.
- `date.toInstant()` - converts a Date object to an Instant.
- `timeZone.toZoneId()` - converts a TimeZone object to a ZoneId.

```
GregorianCalendar gregorianCalendar = new GregorianCalendar();
gregorianCalendar.toZonedDateTime();
```

Lab: Date Time

Step 1: Open *src/test/java/com.xycorp.exercises.datetime.DateTimeExercises*

Step 2: In the test `testIterateWithThreeDays`, initialize `Arrays.asList(1,50,100,200,921)` and convert that list to a `List` of hexadecimals. Research how to convert an `Integer` to hexadecimal. *Do not use* `while` *or* `for` *loops or any old style iteration.*

Step 2: In the test `testWhatDateTimeIsItInBuenosAiresArgentina`, display the current time in Buenos Aires Argentina.

Step 3: In the test `testFindAllAmericasTimeZones`, find all the time zones in the "America", remove the `America` from the Time Zone identifier and sort by the name of the time zone.

Step 4: In the test `testFindAllTimeZonesInAntarctica`, find all the Antarctica Time Zones, sort by their distance from UTC in ascending order, and display nicely the offset, the zone, and whether it adheres to Daylight Saving Time or not.

Generics

- Generics
- Get Put Principles
- Wildcards

Static vs. Dynamic

Generics

- Add stability to your code by making more of your bugs detectable at *compile time* * Enable types (classes and interfaces) to be parameters when defining classes, interfaces and methods.
- Provide a way for you to re-use the same code with different inputs, requiring less code
- Eliminates Casting
- One of the harder concepts in Java Programming since JDK 5.

Effective Java Item 26

Eliminating Casting

Before:

```
List list = new ArrayList();
list.add("hello");
String s = (String) list.get(0);
```

After:

```
List<String> list = new ArrayList<String>();
list.add("hello");
String s = list.get(0);   // no cast
```

Diamond Operator

In Java SE 7, you can substitute the parameterized type of the constructor with an empty set of type parameters (<>):

```
List<String> list = new ArrayList<>();
list.add("hello");
String s = list.get(0);   // no cast
```

Generics with `for`

```
List<Integer> ints = Arrays.asList(1,2,3);
int s = 0;
for (int n : ints) { s += n; }
```

Unreadability without Generics

```
List ints = Arrays.asList( new Integer[] {
  new Integer(1), new Integer(2), new Integer(3)
} );
int s = 0;
for (Iterator it = ints.iterator(); it.hasNext(); ) {
  int n = ((Integer)it.next()).intValue();
  s += n;
}
```

Unreadability with Arrays

```
int[] ints = new int[] { 1,2,3 };
int s = 0;
for (int i = 0; i < ints.length; i++) { s += ints[i]; }
```

Notes:

- Less flexible
- Less readable

Erasure

Comparing these two sets of code:

The following uses generics…

```
List<String> words = new ArrayList<String>();
words.add("Hello ");
words.add("world!");
String s = words.get(0)+words.get(1);
```

The following doesn't and uses a *raw type*.

```
List words = new ArrayList();
words.add("Hello ");
words.add("world!");
String s = ((String)words.get(0))+((String)words.get(1))
```

But at runtime, *they are the same* due to *erasure*.

`List<Integer>`, `List<String>`, and `List<List<String>>` are all represented at run-time by the same type, `List`

Generics vs. Templates

- Generics in Java resemble templates in C++.
- Keep in mind: Syntax and semantics.
  - Syntax is deliberately similar
  - Semantics are deliberately different.

Template Declarations in C++ vs. Generic Declarations in Java

In C++, nested parameters require extra spaces, so you see things like this:

```
List< List<String> >
```

In Java, no spaces are required, and it's fine to write this:

```
List<List<String>>
```

C++ Expansion vs. Java Erasure

- C++ Templates Expansion:
  - Each instance of a template at a new type is compiled separately.
  - e.g If you use a list of integers, a list of strings, and a list of lists of string, there will be three versions of the code. (*code bloat*)
  - Efficient, possible to be optimized
- Java Generics Erasure
  - Erasure doesn't track the generic type at runtime
  - This offers flexibility and less *code bloat* than expansion
  - Maintains safety and ease of use to understand, to a point

Reification

> Reification is making something real, bringing something into being, or making something concrete.

Java's Generics are *not reified* at runtime.

Reification Rationale

Neal Gafter on Reification

> Generics are implemented using erasure as a response to the design requirement that they support migration compatibility: it should be possible to add generic type parameters to existing classes without breaking source or binary compatibility with existing clients.

> Without migration compatibility, the collection APIs could not be retrofitted use generics; we would probably have added a separate, new set of collection APIs that use generics. That was the approach used by C# when generics were introduced, but Java did not take this approach because of the huge amount of pre-existing Java code using collections.

Automatic Boxing of Primitives

```
List<Integer> ints = new ArrayList<>();
ints.add(1); //adding a primitive 1
int n = ints.get(0);
```

This is equivalent to:

```
List<Integer> ints = new ArrayList<>();
ints.add(Integer.valueOf(1));
int n = ints.get(0).intValue();
```

Lab: Discussing Parameterized Classes:

Step 1: In the `src/main/java` folder, and inside the `com.xyzcorp` package.

Step 2: Open `Box.java`

Step 3: Discuss creating `Box` parameterized types.

Lab: Basic Generics Test

Step 1: Create the `src/test/java` directory if necessary.

Step 2: In the `src/test/java` directory, create a package called `com.xyzcorp` if it is not there.

Step 3: Inside the package `com.xyzcorp`, create a java file called `GenericsTest.java` with the following contents:

```
package com.xyzcorp;

public class GenericsTest {

}
```

Lab: Test Using Box

Step 1: In the `GenericsTest.java` file create a test called `testUsingBox` with the following contents.

```
@Test
public void testUsingBox() {
    Box<Integer> box = new Box<>(4);
    assertEquals(new Integer(4), box.getContents());
}
```

Step 2: Run the test.

Lab: Substituting a Type Parameter with a Parameterized Type

You can also substitute a type parameter (i.e., `K`, `V`, `E`, `T`) with a parameterized type

Step 1: In the `GenericsTest.java` file create a test called `testUsingBoxOfBoxInteger` with the following contents.

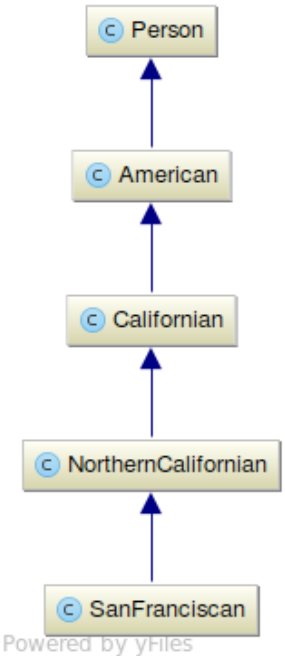
```
@Test
public void testUsingBox() {
   Box<Box<Integer>> box = new Box<>(new Box<>(10));
   assertEquals(new Integer(10), box.getContents().getContents());
}
```

Step 2: Run the test.

Wildcards

Class Diagram of People

For the wildcard generics, we will use the following classes located in `com.xyzcorp.people` package in `src/main/java`



Lab: Invariance

Step 1: Create a test called `testInvariance()` test located in the `GenericsTest` with the following:

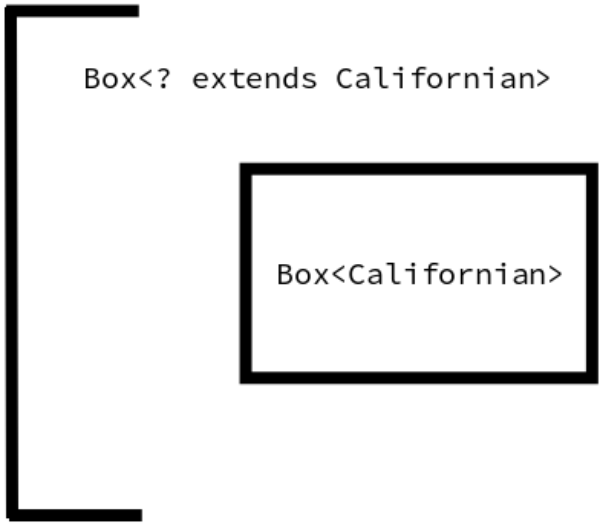
```
@Test
public void testInvariance() {
    //Call by site
    Box<Californian> boxOfCalifornians = new Box<>();

    //Setters OK
    boxOfCalifornians.setContents(new Californian());

    //Getters OK
    Californian californian = boxOfCalifornians.getContents();

    System.out.println("boxOfCalifornians = " + boxOfCalifornians);
}
```

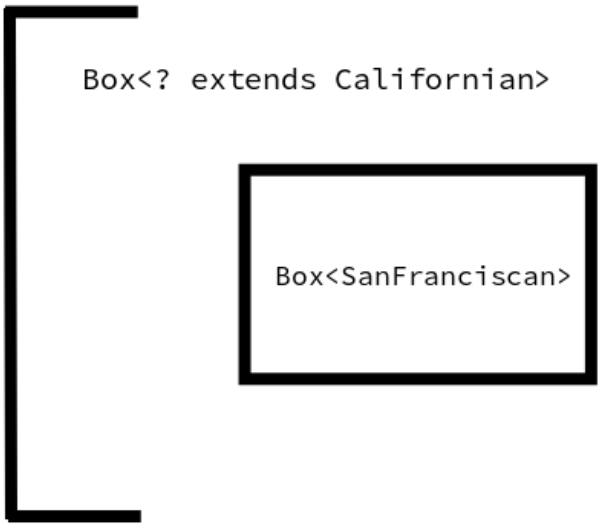
Step 2: Run the test to ensure that it all works.

By default generics are invariant. Meaning that the given `Box` cannot vary in the types used. The Box is *always* going to be a box of `Californians` both on the assignment and instantiation.

Covariance

> `S` is a subtype of `T` iff `List<S>` is a subtype of `List<T>`





Lab: An Attempt at Covariance

Step 1: In the `GenericsTest` add the following test `testCovarianceAssignments`

Step 2: Add the following content:

```
@Test
public void testCovarianceAssignments() {
    Box<NorthernCalifornian> boxOfNorthernCalifornians = new Box<>();

    //This is an attempt at covariance, this will not work
    Box<Californian> boxOfCalifornians = boxOfNorthernCalifornians;
}
```

Step 3: Describe why this did not work.

Lab: Try Other Variance Assignments

Step 1: In the `testCovarianceAssignments` that we have been using up to this point try the following assignments, one by one.

```
@Test
public void testCovarianceAssignments() {
    Box<NorthernCalifornian> boxOfNorthernCalifornians = new Box<>();

    //This is an attempt at covariance, this will not work
    Box<? extends Californian> boxOfCalifornians =
boxOfNorthernCalifornians;
    Box<? extends Object> boxOfObjects = boxOfNorthernCalifornians;
    Box<? extends Person> boxOfPeople = boxOfNorthernCalifornians;
    Box<? extends American> boxOfAmericans = boxOfNorthernCalifornians;
    Box<? extends NorthernCalifornian> boxOfNorthernCalifornians2 =
boxOfNorthernCalifornians;
    Box<? extends SanFranciscan> boxOfSanFranciscans  =
boxOfNorthernCalifornians;
}
```

Step 2: Explain why the last one fails, after reviewing, please comment the last line out.

Lab: `<? extends Object>`

- `<? extends Object>` is nearly equivalent to `<?>`

Step 1: In the test that we are working on change `Box<? extends Object> boxOfObjects = boxOfNorthernCalifornians` to `<?>`

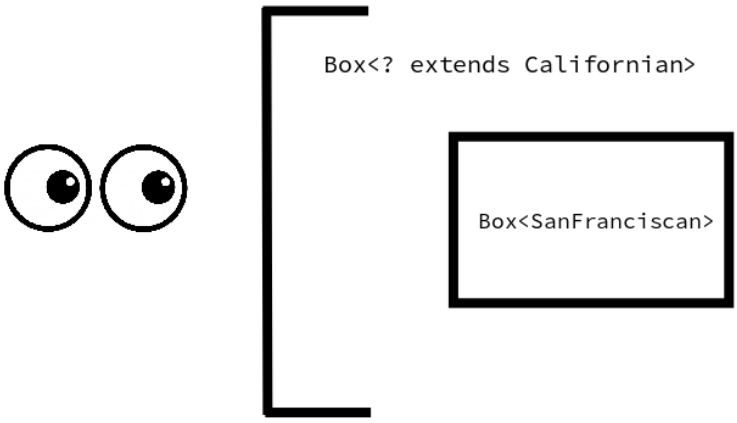
```
@Test
public void testCovarianceAssignments() {
    Box<NorthernCalifornian> boxOfNorthernCalifornians = new Box<>();

    //This is an attempt at covariance, this will not work
    Box<? extends Californian> boxOfCalifornians =
boxOfNorthernCalifornians;
    Box<?> boxOfObjects = boxOfNorthernCalifornians;
    Box<? extends Person> boxOfPeople = boxOfNorthernCalifornians;
    Box<? extends American> boxOfAmericans = boxOfNorthernCalifornians;
    Box<? extends NorthernCalifornian> boxOfNorthernCalifornians2 =
boxOfNorthernCalifornians;
    Box<? extends SanFranciscan> boxOfSanFranciscans  =
boxOfNorthernCalifornians;
}
```

For an interesting discussion of `<?>` edge cases see this StackOverflow article.

Get Principle

The Get Principle

> Use an `extends` wildcard when you only get values out of a structure



Lab: Covariance Get Principle

Step 1: In the `GenericsTest` create a test called `testCovarianceGetPrinciple`

Step 2: In the test itself add the following lines.

```
@Test
public void testCovarianceGetPrinciple() {
    Box<SanFranciscan> boxOfSanFranciscans = new Box<>();
    Box<? extends Californian> californians = boxOfSanFranciscans;

    Object object = californians.getContents();
}
```

Step 3: Object has been provided for you, add lines to see if you can assign to a `Person`, `American`, `Californian`, `Northern Californian`, and `San Franciscan`

Step 4: Comment out what didn't compile.

Step 5: Explain why certain retrievals didn't work

Lab: The Covariance Put Principle

Step 1: In the `GenericsTest` create a new test called `testCovariancePutPrinciple`

Step 2: Start with the following content and work your way down to `San Franciscan` from `Object`

```
@Test
public void testCovariancePutPrinciple() {
    Box<SanFranciscan> boxOfSanFranciscans = new Box<>();
    Box<? extends Californian> californians = boxOfSanFranciscans;

    californians.setContents(new Object());
}
```

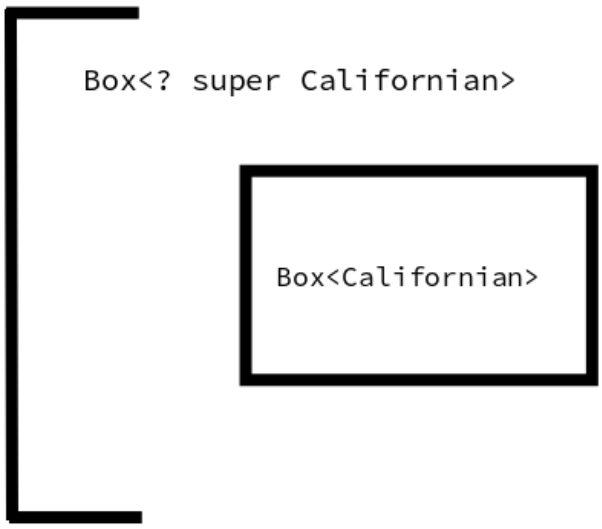
Step 3: Discuss why it is ***not*** safe to "set" information from `californians`

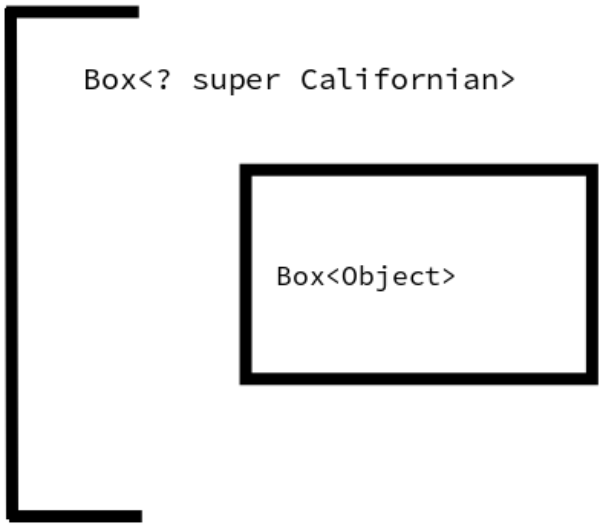
Step 4: Try one more line, `californians.setContents(null)` and explain why that one makes sense.

Step 5: Comment out the lines that did not work.

Contravariance

> `S` is a supertype of `T` iff `List<S>` is a supertype of `List<T>`





Lab: An Attempt at Contravariance

Step 1: In the `GenericsTest` add the following test `testContravarianceAssignments`

Step 2: Add the following content:

```
@Test
public void testContravarianceAssignments() {
   Box<Californian> boxOfCalifornians = new Box<>();

   //This is an attempt at contravariance, this will not work
   Box<? super Object> boxOfObjects = boxOfCalifornians;
}
```

Step 3: Describe why this did not work

Lab: Try Other Variance Assignments

Step 1: In the `testContravarianceAssignments` that we have been using up to this point try the following assignments, one by one.

```
@Test
public void testCovarianceAssignments() {
   Box<Californian> boxOfCalifornians = new Box<>();

   //This is an attempt at contravariance, this will not work
   Box<? super Object> boxOfObjects = boxOfCalifornians;
   Box<? super Person> boxOfPeople = boxOfCalifornians;
   Box<? super American> boxOfAmericans = boxOfCalifornians;
   Box<? super NorthernCalifornian> boxOfNorthernCalifornians =
                boxOfCalifornians;
   Box<? super SanFranciscan> boxOfSanFranciscans =
                boxOfNorthernCalifornians;
}
```

Step 2: Explain why the first three failed.

Lab: Contravariance Get Principle

Step 1: In the `GenericsTest` create a test called `testContravarianceGetPrinciple`

Step 2: In the test itself add the following lines.

```
@Test
public void testContravarianceGetPrinciple() {
    Box<Object> boxOfObjects = new Box<>();
    Box<? super SanFranciscan> boxOfSanFranciscansAndSuperclasses =
boxOfObjects;

    Object object = boxOfSanFranciscansAndSuperclasses.getContents();
}
```

Step 3: Object has been provided for you, add lines to see if you can assign to a `Person`, `American`, `Californian`, `Northern Californian`, and `San Franciscan`

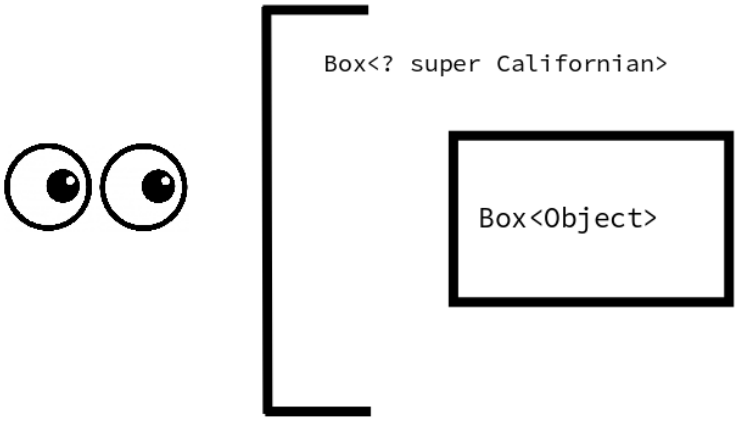
Step 4: Comment out what didn't compile.

Step 5: Explain why most of retrievals minus `Object` didn't work.

Put Principle

The Put Principle

> Use a `super` wildcard when you set values into a structure



Lab: The Contravariance Put Principle

Step 1: In the `GenericsTest` create a new test called `testContravariancePutPrinciple`

Step 2: Start with the following content and work your way down to `San Franciscan` from `Object`

```
@Test
public void testContravariancePutPrinciple() {
   Box<Object> boxOfCalifornians = new Box<>();
   Box<? super Californian> boxOfSanFranciscansAndSuperclasses =
boxOfCalifornians;

   boxOfSanFranciscansAndSuperclasses.setContents(new Object());
}
```

Step 3: Discuss why it is ***not*** safe to

Step 4: Try one more line, `californians.setContents(null)` and explain why that one makes sense.

Step 5: Comment out the lines that did not work.

Using Wildcards in Methods

Step 1: In `GenericsTest` create a test method called `testVariancesInMethod()` with the following content:

```
@Test
public void testVariancesInMethod() {
    List<Integer> items = Arrays.asList(5,10, 12, 10, 19, 44);
    assertEquals(Optional.of(5), findFirst(items));
}
```

Step 2: In the same test file, create a non-test method called `findFirst` that would pass the `testVarianceInMethod`

Step 3: Discuss solution

Generic Method in a Generic Class returning a different type

Often times when a class is parameterized, a method can use another parameterized type either to use in conjuction with the types with the class:

```
class A<T> {
   public <U> U foo(T t) {
      //return a type U
   }
}
```

`U` may or not be different than `T` at runtime, but the potential should be present.

This is incorrect, and is referred to as *type hiding*.

```
class A<T> {
   public <T> T foo(T t) {
      //return a type U
   }
}
```

Generic Static Method in a Generic Class returning a different type

Also when a class is parameterized, a `static` method can use another parameterized type either to use in conjuction with the types with the class.

The type system is different from the object graph. There all types established are applicable whether is is `static` or non-`static`

```
class A<T> {
   public static <U> U foo(T t) {
      //return a type U
   }
}
```

`U` may or not be different than `T` at runtime, but the potential should be present.

This is incorrect, but is not *type hiding*, but is bad and unreadable form.

```
class A<T> {
   public static <T> T foo(T t) {
      //return a type U
   }
}
```

Lab: Creating a generic method in a generic class.

Step 1: In `GenericsTest` create `testMap` with the following content:

```
@Test
public void testMap() throws Exception {
    Box<Integer> box = new Box<>(4);
    Box<String> newBox = box.map(integer ->
              Stream.generate(() -> "Wow")
                .limit(integer)
                .collect(Collectors.joining()));
    System.out.println("newBox = " + newBox);
}
```

Step 2: In `Box.java` add a method called map that takes a `java.util.function.Function` (see Java API)

Step 3: The implementation of `map` should take the function and return a *new* `Box` with the previous state transformed by the function.

Nerd Alert

Multiple Bounds

A type parameter can have multiple bounds

```
<T extends B1 & B2 & B3>
```

If one of the bounds is a class, it must be specified first. For example..

```
class A { /* ... */ }
interface B { /* ... */ }
interface C { /* ... */ }

class D <T extends A & B & C> { /* ... */ }
```

If not you will receive a compile time exception.

```
class D <T extends B & A & C> { /* ... */ }  // compile-time error
```

From The Java Documentation Online

Lab: Multiple Bounds

Step 1: In `src/test/java` and in the package `com.xyzcorp` create another class, `MultipleBoundsTest.java`

Step 2: Create a test in the `MultipleBoundsTest` called `testMultipleInheritance` and an non-test method `foo` with the following content.

```
package com.xyzcorp;

import org.junit.Test;

import java.io.CharArrayWriter;

public class MultipleBoundsTest {

    public <FILL_HERE> void foo(T t) throws IOException {
        t.append('c');
        t.append('d');
        t.flush();
        t.close();
    }

    @Test
    public void testMultipleInheritance() throws IOException {
        CharArrayWriter writer = new CharArrayWriter(40);
        foo(writer);
        System.out.println(writer.toCharArray());
    }
}
```

Step 3: For method `foo` replace what is in `FILL_HERE` with what you suspect the parameterized type `T` should look like if `T` is also `Appendable`, `Closeable`, and `Flushable` (all are interfaces)

`<T extends <Comparable<T>>`

Why does `<T extends Comparable<T>>` look the way it does?

This should make sense.

```
public class Foo implements Comparable<Foo>{
    private int i = 0;
    @Override
    public int compareTo(Foo o) {
        return Integer.valueOf(i).compareTo(o.i);
    }
}
```

But if it was just `Comparable` it would have to look like this:

```
public class Foo implements Comparable {
    private int i = 0;
    @Override
    public int compareTo(Object o) {
        return Integer.valueOf(i).compareTo(o.i);
    }
}
```

Therefore, `<T extends <Comparable<T>>`

Therefore this code should make sense.

```
public class MyCollection<T extends Comparable<T>> {
    private final T[] items;

    public MyCollection(T... items) { //varargs
        this.items = items;
    }

    public Optional<T> max() {
        if (items.length == 0) return Optional.empty();
        T result = items[0];
        for (T item : items) {
            if (item.compareTo(result) > 0) result = item;
        }
        return Optional.of(result);
    }
}
```

The Problem with `<T extends Comparable>`

```
public class MyCollection<T extends Comparable> {
    private final T[] items;

    public MyCollection(T... items) { //varargs
        this.items = items;
    }

    public Optional<T> max() {
        if (items.length == 0) return Optional.empty();
        T result = items[0];
        for (T item : items) {
            if (item.compareTo(result) > 0) result = item;
        }
        return Optional.of(result);
    }
}
```

`item.compareTo(result)` is unchecked because `compareTo` is only expecting `Object` not `T`

Without `<Class<T>>`

We see this everywhere, but what is it? And why does it exist?

Consider:

```
public void listMethodsFromRawClass(Class clazz) {
    clazz.getMethods();
}
```

We can call it with anything.

```
listMethodsFromRawClass(Person.class);  //Not constrained
```

With `<Class<T>>`

With `<Class<T>>` we can constrain the type of classes that are called.

Consider:

```
public void listMethodsFromRawClass(Class<Person> clazz) {
    clazz.getMethods();
}
```

We can call only call with `Person`

```
listMethodsFromRawClass(Person.class);
```

Review JDK Collections library for Generics

Collection interface

Collections

- Before Java 2, all we had were arrays
- Java 2, introduced `java.util.Collection` package
- Java 5, generics were added to make it easier to use with tools

`List`

- Store elements by insertion order
- 0-based index
- Primitives are boxed

`LinkedList`

- A `List` that is composed of a doubly linked list.
- Constant O(1) time adding and removing elements
- Linear O(n) time for other operations
- Not thread safe

`ArrayList`

- Array's size will be automatically expanded
- Constant Time O(1) for the following
  - `size`
  - `isEmpty`
  - `get` and `set`
  - `iterator` and `listIterator`
- Linear O(n) for all other operations
- Not thread safe

`Set`

- No duplicate elements
- Mathematical `Set` meaning there are more mathematical style methods depending on implementation
- A correct `hashCode` and `equals` must be establish on objects added to any `Set`
- Mutable objects should remain consistent or have an expected behavior
- Prefer immutable objects to avoid unexpected behavior

`HashSet`

- `Set` backed up by a Hashtable
- No order
- Constant Time O(n) for `add`, `remove`, `contains`, `size`, if `hashCode` is implemented well.
- Iteration speed is proportional to the size
- Not thread safe

`TreeSet`

- `Set` implements of a `TreeMap`
- Elements are ordered with natural ordering or using a specified `Comparator`
- Made consistent using the `equals` implementation of the contained objects
- Consistent with `equals` requires that `compare` should reflect equality
- All elements are compared using `Comparator` implementation if provided

`Map`

- `Object` that maps key to a value
- Some have specific order, others do not, depending on
- Some implementations will have restrictions on the types of keys or values
- Mutable objects should remain consistent or have an expected behavior
- Prefer immutable objects to avoid unexpected behavior

`TreeMap`

- An implementation of `Map`
- Sorted according to the natural ordering of its keys or a given `Comparator`
- O(log(n)) time for `containsKey`, `get`, `put`, `remove` methods
- If a `Comparator` is not provide, the objects contained must correctly implement `equals`

`HashMap`

- Hash table implementation of `Map`
- Permits `null` keys and values
- Not thread safe
- Constant time for `get` and `put`
- Iteration is time proportional to the capacity
- Determined by two parameters:
  - `initial capacity`: number of buckets
  - `load factory`: how full does the hash table need to before automatically increased

- Rebuilt when entries is greater than the product of load factor and capacity

`Iterator`, `Iterable`, and `Enumeration`

Using `Iterator`

Interface that allows iteration in one direction, forward:

- `hasNext`
- `next`

Using `Iterable`

- `interface` that allows an object to be accepted as way to be included in a `for-each` loop.

Before Java 5:

```
for (Iterator i = suits.iterator(); i.hasNext(); ) {
    Suit suit = (Suit) i.next();
    for (Iterator j = ranks.iterator(); j.hasNext(); )
        sortedDeck.add(new Card(suit, j.next()));
}
```

After Java 5:

```
for (Suit suit : suits)
    for (Rank rank : ranks)
        sortedDeck.add(new Card(suit, rank));
```

From: https://docs.oracle.com/javase/1.5.0/docs/guide/language/foreach.html

Using `ListIterator`

Interface that allows iteration in either direction and include calls for:

- `hasPrevious`
- `previous`

`Enumeration`

- Older way to iterate through collections.
- Has been since less preferred in favor of `Iterator` and `Iterable`

```
for (Enumeration<E> e = v.elements(); e.hasMoreElements();)
    System.out.println(e.nextElement());
```

Source: https://docs.oracle.com/javase/8/docs/api/java/util/Enumeration.html

`Queue` and `Deque`

`Queue`

- A collection designed for holding elements prior to processing.
- Used extensively for asynchronous processing in `java.util.concurrent` package
- Typically FIFO (first in, first out), some implementations may be different.
- In FIFO queues, elements are placed at the end or tail
- Queues will have different sorting algorithms

`Queue` Operations

	Throws Exception	Returns Value
Insert	`add(e)`	`offer(e)`
Remove	`remove()`	`poll()`
Examine	`element()`	`peek()`

`Queue` Addition Operations

	Throws Exception	Returns Value
Insert	`add(e)`	`offer(e)`
Remove	`remove()`	`poll()`
Examine	`element()`	`peek()`

- `offer(e)` will add the element typically at the tail of the `Queue`
- `add(e)` will add the element typically at the tail

`Queue` Removal Operations

	Throws Exception	Returns Value
Insert	`add(e)`	`offer(e)`
Remove	`remove()`	`poll()`
Examine	`element()`	`peek()`

- `poll` will offer the head element or `null` if empty
- `remove` will offer the head element or throw a `NoSuchElementException`

`Queue` Examination Operations

	Throws Exception	Returns Value
Insert	`add(e)`	`offer(e)`
Remove	`remove()`	`poll()`
Examine	`element()`	`peek()`

- `element` will retrieve but not remove the head, throws `NoSuchElementException` if empty
- `peek` will retrieve but not remove the head, returns `null` if empty.

`LinkedList` as a `Queue`

```
Queue<Integer> queue = new LinkedList<Integer>();
queue.add(40);
boolean result = queue.offer(50);
assert(result);
boolean result2 = queue.offer(60);
assert(result2);
assert(queue.peek() == 40);
assert(queue.poll() == 40);
```

`PriorityQueue`

- Queue lined up based on *natural ordering* or provided `Comparator`.
- Disallows non-comparable objects
- The *head* element is the least element
- Ties are broken arbitrarily
- Unbounded, with a internal array that is automatically managed
- Not thread-safe
- O(log(n)) for `offer`, `remove`, `poll`, `add`
- O(n) linear for `remove` and `contains`

`PriorityQueue`

Given:

```
public static class Person {
    private String firstName;
    private String lastName;

    Person(String firstName, String lastName) {..}

    public String getFirstName() {..}

    String getLastName() {..}
}
```

PriorityQueue

Given:

```
public static class PersonComparator implements Comparator<Person> {
    @Override
    public int compare(Person o1, Person o2) {
        return o1.getLastName().compareTo(o2.getLastName());
    }
}
```

PriorityQueue

Using a `PriorityQueue`:

```
Queue<Person> queue = new PriorityQueue<>(new PersonComparator());
queue.offer(new Person("Franz", "Kafka"));
queue.offer(new Person("Jane", "Austen"));
queue.offer(new Person("Leo", "Tolstoy"));
queue.offer(new Person("Lewis", "Carroll"));
assert(queue.peek().getLastName().equals("Austen"));
```

Deque

- Pronounced *deck*
- Double Ended Queue, allows insertion and removal of elements at both end points
- Implements both `Stack` and `Queue` at the same time

`Stack`

- Old collection from Java 1.x that represents a last in first out collection (LIFO)
- Extended the older `Vector` implementation and provided methods that can be treated as a `Stack`
- Preferable to use `Deque` for stack based operations

`Deque` Operations

Deque Methods

Type of Operation	**First Element (Beginning of the `Deque` instance)**	**Last Element (End of the `Deque` instance)**
Insert	`addFirst(e)` `offerFirst(e)`	`addLast(e)` `offerLast(e)`
Remove	`removeFirst()` `pollFirst()`	`removeLast()` `pollLast()`
Examine	`getFirst()` `peekFirst()`	`getLast()` `peekLast()`

Some extra methods of note: `removeFirstOccurence` removes the first occurrence of the specified element if it exists in the `Deque` instance otherwise remains unchanged.

`removeLastOccurence` removes the last occurrence of the specified element in the `Deque` instance. The return type of these methods is `boolean`, and they return `true` if the element exists in the `Deque` instance.

Threads

Threads

- An independent path of execution with code.
- Multiple threads executing within the same program is a *multithreaded application*
- All Threaded code is performed using `java.lang.Thread`
- In every Java application there is a non-daemon (non-background thread)
- All threads will be executed until:
  - `Runtime.exit()` has been called
  - All non-daemon threads have been terminated

Creating a Basic `Thread`

- Two different philosophies
  - extending `Thread`
  - using a `Runnable` and plugging it into a `Thread`

Extending `Thread`

```
class MyThread extends Thread {
   private boolean done = false;

   public void finish() {
      this.done = true;
   }

   public void run() {
       while (!done) {
         try {
           Thread.sleep(1000);
         } catch (InterruptedException ie) {
           //ignore
         }
         System.out.print(String.format("In Run: [%s] %s\r\n",
             Thread.currentThread().getName(), LocalDateTime.now()));
       }
   }
}
```

Threads with `Runnable`

- A Thread can be created with instances of the `Runnable` interface
- `Runnable` interface has a `run` method and what is used in the interface is what is run.
- Perfect to have plug the same behavior into multiple `Thread`

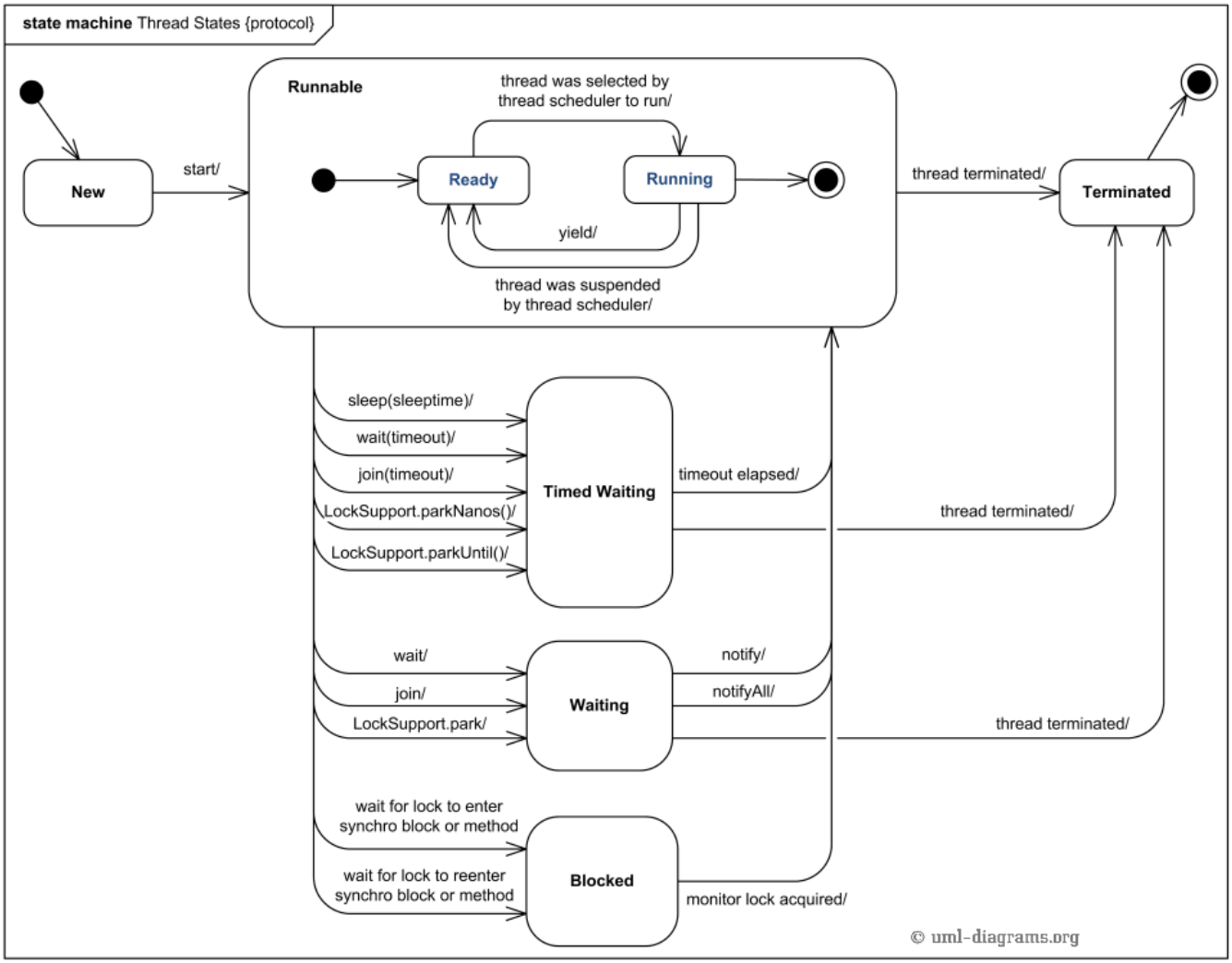
Lab: Create a `Thread` with `Runnable`

```
class MyRunnable implements Runnable {
   private boolean done = false;

   public void finish() {
      this.done = true;
   }

   public void run() {
       while (!done) {
         try {
           Thread.sleep(1000);
         } catch (InterruptedException ie) {
           //ignore
         }
         System.out.print(String.format("In Run: [%s] %s\r\n",
             Thread.currentThread().getName(), LocalDateTime.now()));
       }
   }
}
```

Common `Thread` methods

- `void interrupt()` sends an interrupt signal to a `Thread`
- `static boolean interrupted()` tests if the current `Thread` is interrupted
- `isInterrupted` tests whether a `Thread` is interrupted
- `currentThread` retrieves the current `Thread` in the current scope

Thread states



Thread priorities

- Each thread have a priority.
- Priorities are represented by a number between `1` and `10`.
- Thread Schedulers schedules the threads according to their priority (known as preemptive scheduling).
- Indeterminate because it depends on JVM specification that which scheduling it chooses.
- Predefined constants are available:
  - `MIN_PRIORITY`
  - `MAX_PRIORITY`
  - `NORM_PRIORITY`

`join`

Join allows one thread to wait for another thread to complete. If Thread `t` is running, then the following will cause the current running `Thread` to wait until `t` is done.

```
t.join() //Wait for Thread t to finish and block
```

Lab: `join` Threads

Step 1: In the `ThreadsTest.java` file and in the `com.xyzcorp` package, add the test `testThreadJoin` with the following

```
@Test
public void testThreadJoin() throws InterruptedException {
    Thread thread1 = new Thread() {
        @Override
        public void run() {
            try {
                Thread.sleep(2000);
            } catch (InterruptedException e) {
                e.printStackTrace();
            }
            System.out.format("Did two seconds on Thread %s\n", Thread
.currentThread().getName());
        }
    };

    thread1.start();
    thread1.join();
    System.out.println("Thread test done");
}
```

Step 2: Run the test

Step 3: Verify the behavior of a join

Daemon Threads

- A daemon thread is a thread that doesn't prevent the JVM from exiting when the thread finishes
- An example of a daemon thread is the garbage collection thread
- Use `setDaemon` to set the `Thread` to a daemon `Thread`.

Lab: Daemon Threads

Step 1: A little different kind of lab, create a class called `DaemonRunner.java` in the `src/main/java` folder:

Step 2: Ensure that it has the following content:

```
public class DaemonRunner {
    public static void main(String[] args) {
        Thread t = new Thread() {
            @Override
            public void run() {
                while(true) {
                    try {
                        Thread.sleep(2000);
                    } catch (InterruptedException e) {
                        e.printStackTrace();
                    }
                    System.out.println("Going...");

                }
            }
        };
        //t.setDaemon(true); //Run first then uncomment
        t.start();
    }
}
```

Step 3: Run and notice that this will continue running until the application is forced to terminate.

Step 4: Uncomment the line `//t.setDaemon(true)` and run again then notice the difference

Immutability

- Immutability is not having the capability of changing an object
- Any change to an object provides a copy

```
public class Person {
    private final String firstName;
    private final String lastName;

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

    public String getFirstName() {
        return firstName;
    }

    public String getLastName() {
        return lastName;
    }

    //equals, hashCode, toString
```

- Processor caching does not need to exchange state.
- Desirable in modern applications.

Race Conditions

- A race condition occurs when two threads or more race to a resource and at the time it is in undesired state.

An inappropriate Singleton

```
public class MySingleton {
   private static MySingleton instance = null;
   private MySingleton() { }
   public static MySingleton getInstance() {
      if(instance == null) { //What happens when two threads attack
this?
         instance = new MySingleton();
      }
      return instance;
   }
}
```

Locks

Intrinsic Locks

- An intrinsic lock is a lock that is innate within the language and provided depending where it is used
- Often called a "monitor lock"
- Intrinsic locks can either be established on a method using the `synchronized` keyword on the method
- Intrinsic locks can also be established on a your selected object
- All threads must establish an "intrinsic lock" on the object.
- Constructors cannot be synchronized since one thread creates objects

Intrinsic Lock on a Method

- The following example shows an intrinsic lock that locks on the `Account` instance that is created

```
class Account {
  private int amount;

  public synchronized void deposit(int amount) {
     this.amount = amount;
  }
}
```

Intrinsic Lock on `this`

```
class Account {
  private int amount;

  public void deposit(int amount) {
     synchronized(this) { // Synchronized on the account object
        this.amount = amount;
     }
  }
}
```

Intrinsic Lock on an external object

```
class Account {
  private Object lock;
  private int amount;
  public Account(Object lock) {
     this.lock = lock;
  }
  public void deposit(int amount) {
     synchronized(lock) { // Synchronized on the account object
        this.amount = amount;
     }
  }
}
```

Intrinsic Lock on a `class`

```
class Account {
  private Object lock;
  private int amount;
  public Account(Object lock) {
     this.lock = lock;
  }
  //The static makes the class become the lock
  public static synchronized void deposit(int amount) {
     this.amount = amount;
  }
}
```

`wait`, `notify`, `notifyAll`

- `wait()` - Causes the current thread to block in the given object until awakened by a `notify()` or `notifyAll()`.
- `notify()`
  - Causes a randomly selected thread waiting on this object to be awakened.
  - It must then try to regain the intrinsic lock.
  - If the "wrong" thread is awakened, your program can deadlock.
- `notifyAll()`
  - Causes all threads waiting on the object to be awakened
  - Each will then try to regain the monitor lock. Hopefully one will succeed.

Lab: `ResourceThrottle`

Step 1: Create a class called `ResourceThrottle` in `src/main/java` with the following content:

```
package com.xyzcorp;

public class ResourceThrottle {
    private int resourcecount = 0;
    private int resourcemax = 1;

    public ResourceThrottle (int max) {
        resourcecount = 0;
        resourcemax = max;
    }

    public synchronized void getResource (int numberof) {
        while (true) {
            if ((resourcecount + numberof) <= resourcemax) {
                resourcecount += numberof;
                break;
            }
            try {
                wait();
            } catch (Exception e) {}
        }
    }

    public synchronized void freeResource (int numberof) {
        resourcecount -= numberof;
        notifyAll();
    }
}
```

Step 2: Describe the contents of `ResourceThrottle`

Step 3: Create a test in `src/test/java` called `ResourceThrottleTest` that exercises the example.

Volatile Fields

- Volatile files are a flag that the memory is to be read on main memory and not the CPU cache
- If each processor is in charge of it's piece of memory per object they would need to synchronize that state.
- Adding `volatile` to the member variable will avoid "visibility issues"

`volatile` field first guarantee

- If Thread-1 writes to a volatile variable and Thread-2 reads the same variable, all variables visible to Thread-1 before writing the `volatile` variable will flushed to main memory will be visible to the Thread-2
- Reading or Writing by the JVM cannot be rerordered, whatever instructions are meant to happen after the write.

Atomics

- List of values that can be updated atomically.
- Lock-free
- Thread-safe
- Extends the notion of a `volatile` values, fields, and array elements
- All contain the update form of:

```
boolean compareAndSet(expectedValue, updateValue);
```

Atomic Values, Arrays, and Fields

- List of atomics values include:
  - `AtomicBoolean`
  - `AtomicInteger`
  - `AtomicIntegerArray`
  - `AtomicIntegerFieldUpdater`
  - `AtomicLong`
  - `AtomicLongArray`
  - `AtomicLongFieldUpdater`

Atomic References

- `AtomicMarkableReference<V>`

- `AtomicReference<V>`
- `AtomicReferenceArray<E>`
- `AtomicReferenceFieldUpdater<T,V>`
- `AtomicStampedReference<V>`

Without Atomic Variables

Instead of the following `Counter` that is `synchronized` we can opt for an Atomic variable as seen in the next slide.

```
class Counter {
    private int c = 0;

    public synchronized void increment() {
        c++;
    }

    public synchronized void decrement() {
        c--;
    }

    public synchronized int value() {
        return c;
    }
}
```

With Atomic Variables

```
import java.util.concurrent.atomic.AtomicInteger;

class AtomicCounter {
    private AtomicInteger c = new AtomicInteger(0);

    public void increment() {
        c.incrementAndGet();
    }

    public void decrement() {
        c.decrementAndGet();
    }

    public int value() {
        return c.get();
    }
}
```

Deadlocks

- Two or more threads are blocked forever without resolution
- Each thread is waiting on a lock but the other thread has a lock

Alphonse and Gaston Example

From: https://docs.oracle.com/javase/tutorial/essential/concurrency/deadlock.html

```
class Friend {
  private final String name;
  public Friend(String name) {
      this.name = name;
  }
  public String getName() {
      return this.name;
  }
  public synchronized void bow(Friend bower) {
      System.out.format("%s: %s"
          + "  has bowed to me!%n",
          this.name, bower.getName());
      bower.bowBack(this);
  }
  public synchronized void bowBack(Friend bower) {
   System.out.format("%s: %s"
             + " has bowed back to me!%n",
             this.name, bower.getName());
   }
}
```

Alphonse and Gaston held up

```
public class DeadlockRunner {
 public static void main(String[] args) {
        final Friend alphonse =
            new Friend("Alphonse");
        final Friend gaston =
            new Friend("Gaston");
        new Thread(new Runnable() {
            public void run() { alphonse.bow(gaston); }
        }).start();
        new Thread(new Runnable() {
            public void run() { gaston.bow(alphonse); }
        }).start();
    }
}
```

Livelock

- Livelock occurs when two threads are expecting a state from each other but never make it.
- Thread-1 acts as a response to action of Thread-2
- Thread 2 acts as a response to action of Thread-1

The `Criminal` and `Police`

- The `Criminal` demands payment to release the hostage
- The `Police` is waiting for the `Criminal` to release the hostage to receive payment

First the `Criminal`

```
public class Criminal {
    private boolean hostageReleased = false;

    public void releaseHostage(Police police) {
        while (!police.isMoneySent()) {

            System.out.println(
              "Criminal: waiting police to give ransom");

            try {
                Thread.sleep(1000);
            } catch (InterruptedException ex) {
                ex.printStackTrace();
            }
        }

        System.out.println("Criminal: released hostage");

        this.hostageReleased = true;
    }

    public boolean isHostageReleased() {
        return this.hostageReleased;
    }
}
```

Then the `Police`

```
public class Police {
    private boolean moneySent = false;

    public void giveRansom(Criminal criminal) {
        while (!criminal.isHostageReleased()) {
            System.out.println(
               "Police: waiting criminal to release hostage");
            try {
                Thread.sleep(1000);
            } catch (InterruptedException ex) {
                ex.printStackTrace();
            }
        }

        System.out.println("Police: sent money");
        this.moneySent = true;
    }

    public boolean isMoneySent() {
        return this.moneySent;
    }
}
```

Running the Livelock

```
static final Police police = new Police();
static final Criminal criminal = new Criminal();

Thread t1 = new Thread(new Runnable() {
    public void run() {
        police.giveRansom(criminal);
    }
});
t1.start();

Thread t2 = new Thread(new Runnable() {
    public void run() {
        criminal.releaseHostage(police);
    }
});
t2.start();
```

From: http://www.codejava.net/java-core/concurrency/understanding-deadlock-livelock-and-starvation-with-code-examples-in-java

Starvation

- When one greedy thread takes on a resource and doesn't relinquish control
- Either occurs because:
  - One `Thread` priority is higher and will never let go of a resource
  - A `Thread` doesn't finish the job

Starvation by never finishing the job

```
import java.io.*;

public class Worker {

    public synchronized void work() {
        String name = Thread.currentThread().getName();
        String fileName = name + ".txt";

        try (
            BufferedWriter writer =
               new BufferedWriter(new FileWriter(fileName));
        ) {
            writer.write("Thread " + name + " wrote this mesasge");
        } catch (IOException ex) {
            ex.printStackTrace();
        }

        while (true) { //Keep going and never let go
            System.out.println(name + " is working");
        }
    }
}
```

Java 5 Concurrent Features

Reentrant Locks

- Same semantics as an implicit monitor lock accessed by `synchronized`
- The `RentrantLock` is owned by the thread last successfully locking, but not unlocking
- May contain a `fairness` operator, when `true`, favors longer waiting threads
- Standard practice to use a `try`/`catch` block to access the lock and unlock

```
class X {
   private final ReentrantLock lock = new ReentrantLock();
   // ...

   public void m() {
     lock.lock();  // block until condition holds
     try {
       // ... method body
     } finally {
       lock.unlock()
     }
   }
 }
```

This lock supports a maximum of 2147483647 recursive locks by the same thread

From: https://docs.oracle.com/javase/7/docs/api/java/util/concurrent/locks/ReentrantLock.html

Thread safe collections

- `BlockingQueue` defines a first-in-first-out data structure that blocks or times out when you attempt to add to a full queue, or retrieve from an empty queue. `
- `ConcurrentMap` is a subinterface of java.util.Map that defines useful atomic operations. These operations remove or replace a key-value pair only if the key is present, or add a key-value pair only if the key is absent. Making these operations atomic helps avoid synchronization. The standard general-purpose implementation of `ConcurrentMap` is `ConcurrentHashMap`, which is a concurrent analog of `HashMap`.
- `ConcurrentNavigableMap` is a subinterface of `ConcurrentMap` that supports approximate matches. The standard general-purpose implementation of `ConcurrentNavigableMap` is `ConcurrentSkipListMap`, which is a concurrent analog of `TreeMap`.

Futures

> Future def. - Future represents the lifecycle of a task and provides methods to test whether the task has completed or has been cancelled.

> Future can only move forwards and once complete it stays in that state forever.

Thread Pools

Before setting up a future, a thread pool is required to perform an asynchronous computation. Each pool with return an `ExecutorService`.

There are a few thread pools to choose from:

- `FixedThreadPool`
- `CachedThreadPool`
- `SingleThreadExecutor`
- `ScheduledThreadPool`
- `ForkJoinThreadPool`

Fixed Thread Pool

- "Creates a thread pool that reuses a fixed number of threads operating off a shared unbounded queue."
- Keeps threads constant and uses the queue to manage tasks waiting to be run
- If a thread fails, a new one is created in its stead
- If all threads are taken up, it will wait on an unbounded queue for the next available thread

Cached Thread Pool

- Flexible thread pool implementation that will reuse previously constructed threads if they are available
- If no existing thread is available, a new thread is created and added to the pool
- Threads that have not been used for sixty seconds are terminated and removed from the cache

Single Thread Executor

- Creates an Executor that uses a single worker thread operating off an unbounded queue
- If a thread terminates due to a failure during execution prior to shutdown, a new one will take its place if needed to execute subsequent tasks.

Scheduled Thread Pool

- Can run your tasks after a delay or periodically
- This method does not return an `ExecutorService`, but a `ScheduledExecutorService`
- Runs periodically until `canceled()` is called.

Fork Join Thread Pool

- An `ExecutorService`, that participates in *work-stealing*
- By default when a task creates other tasks (`ForkJoinTasks`) they are placed on the same on queue as the main task.
- *Work-stealing* is when a processor runs out of work, it looks at the queues of other processors and "steals" their work items.
- Not a member of Executors. Created by instantiation
- Brought up since this will be in many cases the "default" thread pool on the JVM

Basic Future Blocking (JDK 5)

```
ExecutorService fixedThreadPool = Executors.newFixedThreadPool(5);

Callable<Integer> callable = new Callable<Integer>() {
    @Override
    public Integer call() throws Exception {
        System.out.println("Inside ze future: " +
                Thread.currentThread().getName());
        System.out.println("Future priority: " +
          Thread.currentThread().getPriority());
        Thread.sleep(5000);
        return 5 + 3;
    }
};

System.out.println("In test:" + Thread.currentThread().getName());
System.out.println("Main priority" + Thread.currentThread().
getPriority());
Future<Integer> future = fixedThreadPool.submit(callable);

//This will block
Integer result = future.get(); //block
System.out.println("result = " + result);
```

Basic Future Asynchronous (JDK 5)

```
ExecutorService cachedThreadPool = Executors.newCachedThreadPool();

Callable<Integer> callable = new Callable<Integer>() {
    @Override
    public Integer call() throws Exception {
        Thread.sleep(3000);
        return 5 + 3;
    }
};

Future<Integer> future = cachedThreadPool.submit(callable);

//This is proper asynchrony
while (!future.isDone()) {
    System.out.println("I am doing something else on thread: " +
            Thread.currentThread().getName());
}

Integer result = future.get();
```

Futures with Parameters

- `Future` with a parameter will require a parameter be made with method and use a `final` variable for the future

Lab: Creating a Future with a Parameter

Step 1: Create the following test in the `src/test/java` folder in the `FuturesTest.java` file

```
private Future<Stream<String>> downloadingContentFromURL(final String
url) {
    ExecutorService cachedThreadPool = Executors.newCachedThreadPool();
    return cachedThreadPool.submit(new Callable<Stream<String>>() {
        @Override
        public Stream<String> call() throws Exception {
            URL netUrl = new URL(url);
            URLConnection urlConnection = netUrl.openConnection();
            BufferedReader reader = new BufferedReader(
                    new InputStreamReader(
                            urlConnection.getInputStream()));
            return reader
                    .lines()
                    .flatMap(x -> Arrays.stream(x.split(" ")));
        }
    });
}
```

Step 2: Ensure it compiles, and explain what is possibly happening.

Lab : Test the `Future` with a parameter

Step 1: In `src/test/java` in the `FuturesTest.java` file create `testGettingURL` with the following content:

```
@Test
public void testGettingUrl() throws ExecutionException,
InterruptedException {
    Future<Stream<String>> future = downloadingContentFromURL
            (<FILL_IN_WEBSITE>);
    while (!future.isDone()) {
        Thread.sleep(1000);
        System.out.println("Doing Something Else");
    }
    Stream<String> allStrings = future.get();
    allStrings
            .filter(x -> x.contains("Ohio"))
            .forEach(System.out::println);
    Thread.sleep(5000);
}
```

Completable Future

- Staged Completions of Interface `java.util.concurrent.CompletionStage<T>`
- Ability to chain functions to `Future<V>`
- Analogies
  - `thenApply(…)` = map
  - `thenCompose(…)` = flatMap
  - `thenCombine(…)` = independent combination
  - `thenAccept(…)` = final processing

Lab: Setting up the `CompletableFuture`

Step 1: Setup the following member variables in `FuturesTest`

```
private CompletableFuture<Integer> integerFuture1;
private CompletableFuture<Integer> integerFuture2;
private CompletableFuture<String> stringFuture1;
private ExecutorService executorService;
```

Lab: Create A Thread Pool and an asynchronous `CompletableFuture`

Step 1: In a method called `setUp` and annotated with `@Before` establish an `ExecutorService` and the first `CompletableFutures`

```
@Before
public void setUp() {
   executorService = Executors.newCachedThreadPool();


  integerFuture1 = CompletableFuture
          .supplyAsync(new Supplier<Integer>() {
              @Override
              public Integer get() {
                  try {
                      System.out.println("intFuture1 is Sleeping in
thread: "
                              + Thread.currentThread().getName());
                      Thread.sleep(3000);
                  } catch (InterruptedException e) {
                      e.printStackTrace();
                  }
                  return 5;
              }
          });
}
```

Lab: Create two more asynchronous `CompletableFuture`

Step 1: In a method called `setUp` and annotated with `@Before` establish two more `CompletableFuture`

```
@Before
public void setUp() {

  ...

  integerFuture2 = CompletableFuture
          .supplyAsync(() -> {
              try {
                  System.out.println("intFuture2 is sleeping in thread:
"
                          + Thread.currentThread().getName());
                  Thread.sleep(400);
              } catch (InterruptedException e) {
                  e.printStackTrace();
              }
              return 555;
          }, executorService);

  stringFuture1 = CompletableFuture
          .supplyAsync(() -> {
              try {
                  System.out.println("stringFuture1 is sleeping in
thread: "
                          + Thread.currentThread().getName());
                  Thread.sleep(4300);
              } catch (InterruptedException e) {
                  e.printStackTrace();
              }
              return "Los Angeles, CA";
          });
}
```

Lab: Using the `CompletableFuture` with `thenAccept`

Step 1: In `FuturesTest` create a test method called `completableFutureWithThenAccept` with the following:

```
@Test
public void completableFutureWithThenAccept() throws
InterruptedException {
    integerFuture1.thenAccept(System.out::println);
    Thread.sleep(5000);
}
```

Step 2: Describe why there is a `sleep` at the end of this method.

Step 3: Run the test

Lab: Using an equivalent `map` with `thenApply`

Step 1: In `FuturesTest` create a test method called `completableFutureWithThenApply` with the following:

```
@Test
public void completableFutureWithThenApply() throws InterruptedException
{
    CompletableFuture<String> future =
            integerFuture1.thenApply(x -> {
                System.out.println("In Block:" +
                        Thread.currentThread().getName());
                return "" + (x + 19);
            });
    future.thenAccept(s -> {
        System.out.println(Thread.currentThread().getName());
        System.out.println(s);
    });
    Thread.sleep(5000);
}
```

Step 2: Run the test

Lab: Using an equivalent `map` with `thenApplyAsync`

- `thenApplyAsync` will apply a map but will do so on another `Thread`

Step 1: In `FuturesTest` create a test method called `completableFutureWithThenApplyAsync` with the following:

```
@Test
public void completableFutureWithThenApplyAsync() throws
InterruptedException {
    CompletableFuture<String> thenApplyAsync =
            integerFuture1.thenApplyAsync(x -> {
                System.out.println("In Block:" +
                        Thread.currentThread().getName());
                return "" + (x + 19);
            }, executorService);
    Thread.sleep(5000);

    thenApplyAsync.thenAcceptAsync((x) -> {
        System.out.println("Accepting in:" + Thread.currentThread
().getName());
        System.out.println("x = " + x);
    });

    System.out.println("Main:" + Thread.currentThread().getName());
    Thread.sleep(3000);
}
```

Step 2: Run the test

Lab: thenRun

- `thenRun` will run any block after the chain of `CompleteableFuture`
- It will return a `CompletableFuture<Void>` so essentially it is sentinel.

Step 1: In `FuturesTest` create a test method called `completableFutureWithThenRun` with the following:

```
@Test
public void completableFutureWithThenRun() throws InterruptedException {
    integerFuture1.thenRun(new Runnable() {
        @Override
        public void run() {
            String successMessage =
                    "I am doing something else once" +
                            " that future has been triggered!";
            System.out.println
                    (successMessage);
        }
    });
    Thread.sleep(3000);
}
```

Step 2: Run the test

Lab: Trapping Errors with `exceptionally`

- Exceptionally takes an error exception if anywhere on the chain there is an `Exception` thrown

Step 1: In `FuturesTest` create a test method called `completableFutureWithExceptionally` with the following:

```
@Test
public void completableFutureExceptionally() throws InterruptedException
{
    stringFuture1.thenApply((s) -> Integer.parseInt(s))
            .exceptionally(t -> {
                //t.printStackTrace();
                return -1;}).thenAccept(System.out::println);
    System.out.println("This message should appear first.");
    Thread.sleep(6000);
}
```

Step 2: Run the test

Lab: Trapping Errors with `handle`

- If you wish to handle the error based on both a successful output or an exception, use `handle`

Step 1: In `FuturesTest` create a test method called `completableFutureWithHandle` with the following:

```
stringFuture1.thenApply((s) -> Integer.parseInt(s)).handle(
        new BiFunction<Integer, Throwable, Integer>() {
            @Override
            public Integer apply(Integer item, Throwable throwable) {
                if (throwable == null) return item;
                else return -1;
            }
        }).thenAccept(System.out::println);

Thread.sleep(6000);
```

Step 2: Run the test

Lab: `flatMap` with `compose`, but first a `ComposableFuture` with a parameter

- Notice the structure is the same as a regular `Future` with a parameter
- We need to encapsulate the future in a method using the parameter

Step 1: Create a method in `FuturesTest` called `getTemperatureInFahrenheit` with the following:

```
public CompletableFuture<Integer>
    getTemperatureInFahrenheit(final String cityState) {
    return CompletableFuture.supplyAsync(() -> {
        //We go into a webservice to find the weather...
        System.out.println("In getTemperatureInFahrenheit: " +
                Thread.currentThread().getName());
        System.out.println("Finding the temperature for " + cityState);
        return 78;
    });
}
```

Step 2: Ensure that there are no errors

Lab: Using `compose`

- `compose` is `flatMap` for `CompletableFuture` and allows you to build off one another

Step 1: Create a test in `FuturesTest` called `completableCompose` with the following:

```
@Test
public void completableCompose() throws InterruptedException {
    CompletableFuture<Integer> composition =
            stringFuture1.thenCompose(s -> getTemperatureInFahrenheit(
s));
    composition.thenAccept(System.out::println);
    Thread.sleep(6000);
}
```

Step 2: Run the test

Lab: Using `combine`

- `combine` is not reliant on another's evaluation but is used as a `join` to join the `CompletableFuture`

Step 1: Create a test in `FuturesTest` called `completableCombine` with the following:

```
@Test
public void completableCombine() throws InterruptedException {
    CompletableFuture<Integer> combine =
            integerFuture1
                    .thenCombine(integerFuture2, (x, y) -> x + y);
    combine.thenAccept(System.out::println);
    Thread.sleep(6000);
}
```

Step 2: Run the test

A Promise is a `Promise`

- A promise is a `Future` that not determined by calculation
- There is no `Promise` construct in Java per se
- You can use a `CompletableFuture` to perform the action of a Promise

Lab: Creating a Promise using `CompletableFuture`

Step 1: Create a test in `FuturesTest` called `testCompletableFuturePromise` with the following:

```
@Test
public void testCompletableFuturePromise() throws InterruptedException {
    CompletableFuture<Integer> completableFuture =
            new CompletableFuture<>();

    completableFuture.thenAccept(System.out::println);

    System.out.println("Processing something else");
    Thread.sleep(1000);
    completableFuture.complete(42);
    Thread.sleep(3000);
}
```

Step 2: Run the test

Step 3: Discuss the how this is a Promise

Thank You

- Email: dhinojosa@evolutionnext.com
- Github: https://www.github.com/dhinojosa
- Twitter: http://twitter.com/dhinojosa
- Linked In: http://www.linkedin.com/in/dhevolutionnext