Java 8

Daniel Hinojosa

Todo

- Composing Functions
- Laziness
- Parallelism
- Collect
- Multiline functions
- Closures
- Object::toString instead
- Reusing Streams
- No mutable state, Processing

Java 8 Topics

What you will learn in this course:

- Lambdas
- Method References
- `Optional`
- `Stream`
- Default Methods
- `CompletableFuture`
- Date Time API

What's new in Java 8?

What's new in Java 8?

For the Java Programming Language:

- Lambda Expressions, a new language feature, has been introduced in this release. They enable you to treat functionality as a method argument, or code as data. Lambda expressions let you express instances of single-method interfaces (referred to as functional interfaces) more compactly.
- Method references provide easy-to-read lambda expressions for methods that already have a name.
- Default methods enable new functionality to be added to the interfaces of libraries and ensure binary compatibility with code written for older versions of those interfaces.
- Repeating Annotations provide the ability to apply the same annotation type more than once to the same declaration or type use.

- Type Annotations provide the ability to apply an annotation anywhere a type is used, not just on a declaration. Used with a pluggable type system, this feature enables improved type checking of your code.
- Improved type inference.
- Method parameter reflection.

Source: http://www.oracle.com/technetwork/java/javase/8-whats-new-2157071.html

Lab: Pre-Class Check

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

- JDK 1.8.x
- Maven 3.3.x

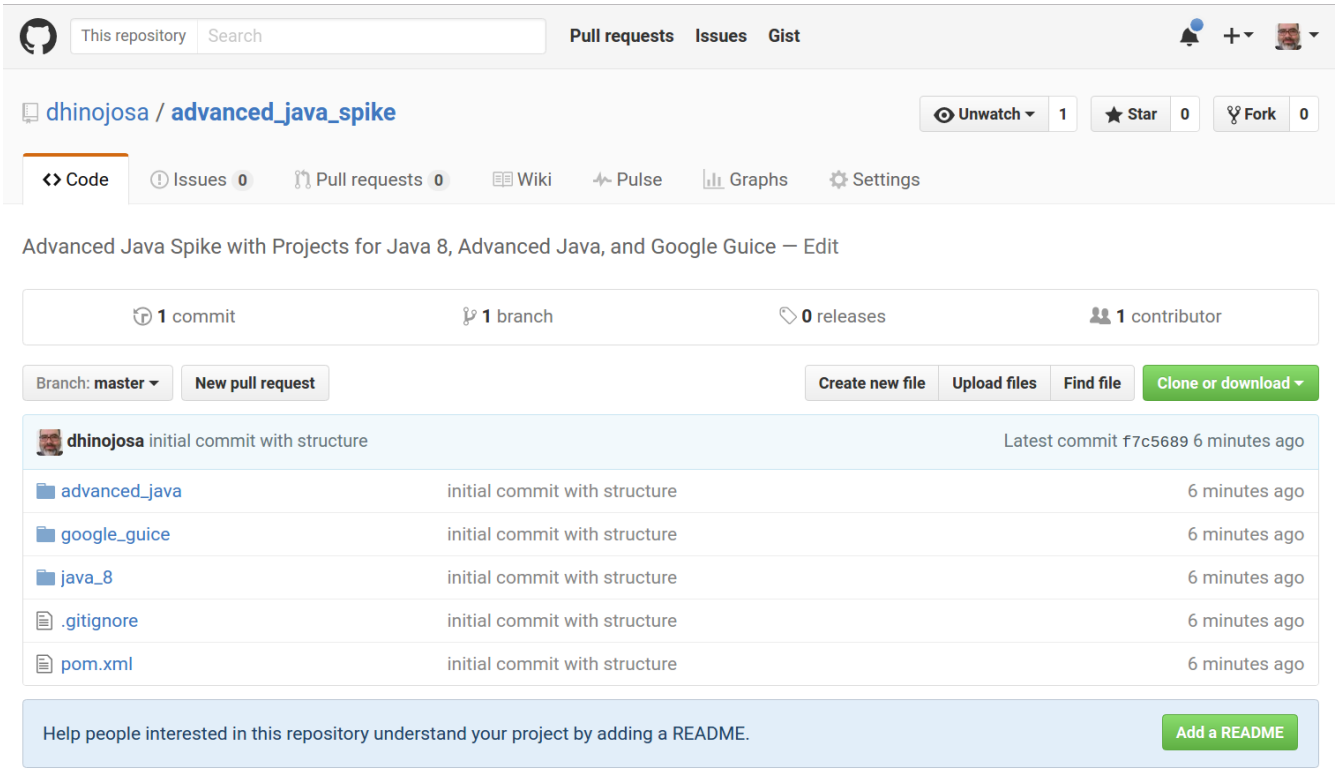
To verify that all your tools work as expected

```
% javac -version
javac 1.8.0_65

% java -version
java version "1.8.0_65"
Java(TM) SE Runtime Environment (build 1.8.0_65-b17)
Java HotSpot(TM) 64-Bit Server VM (build 25.65-b01, mixed mode)

% mvn -v
Apache Maven 3.3.9 (bb52d8502b132ec0a5a3f4c09453c07478323dc5; 2015-11-10T09:41:47-
07:00)
Maven home: /usr/lib/mvn/apache-maven-3.3.9
Java version: 1.8.0_65, vendor: Oracle Corporation
Java home: /usr/lib/jvm/jdk1.8.0_65/jre
Default locale: en_US, platform encoding: UTF-8
OS name: "linux", version: "4.4.0-34-generic", arch: "amd64", family: "unix"
```

NOTE The JDK 8 Version doesn't have to be exact as long as it is Java 8.

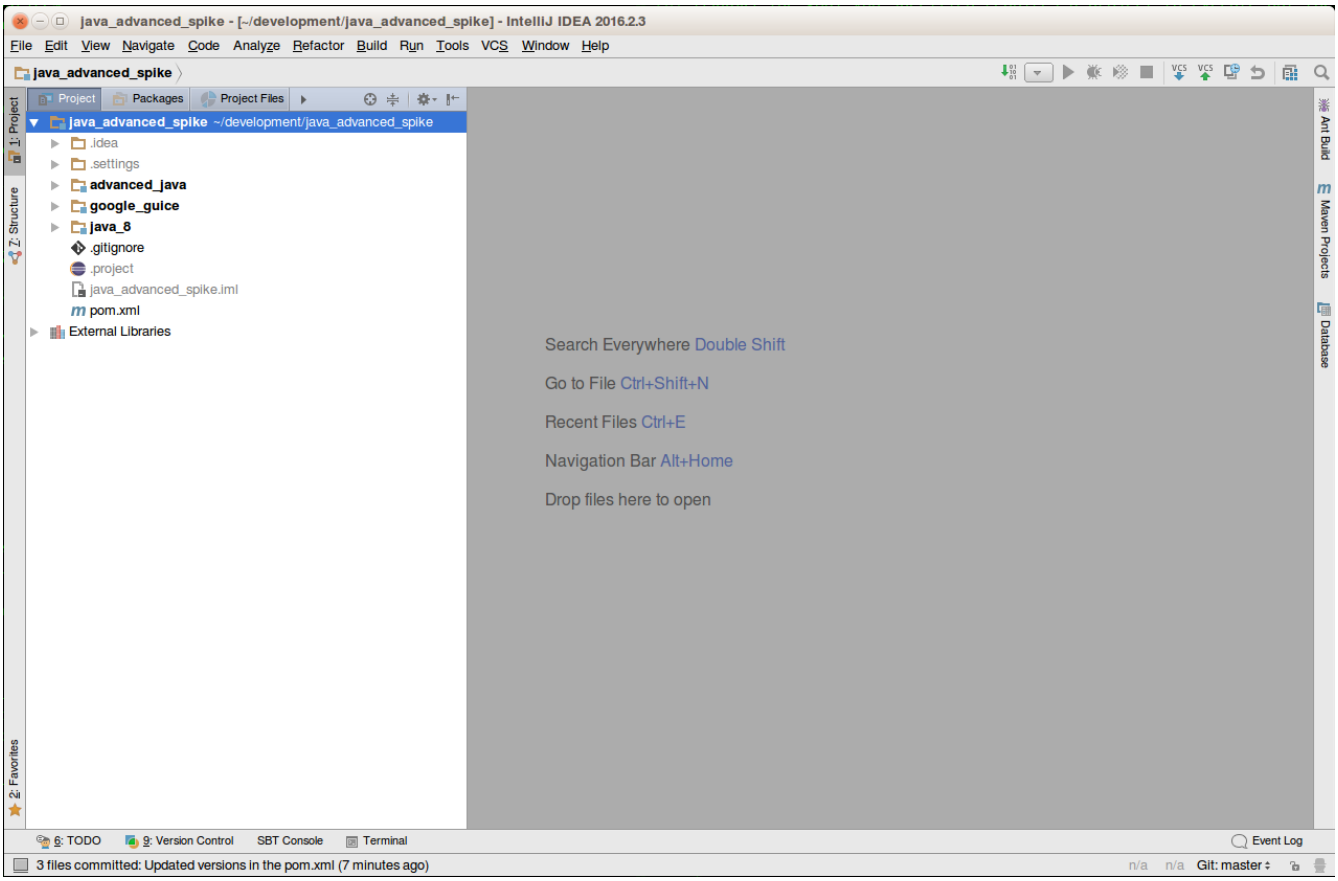
Lab: Download the three day project

From https://github.com/dhinojosa/advanced_java_spike download the project .zip file and extract it into your favorite location.



Optional Lab: Open Project in IntelliJ

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

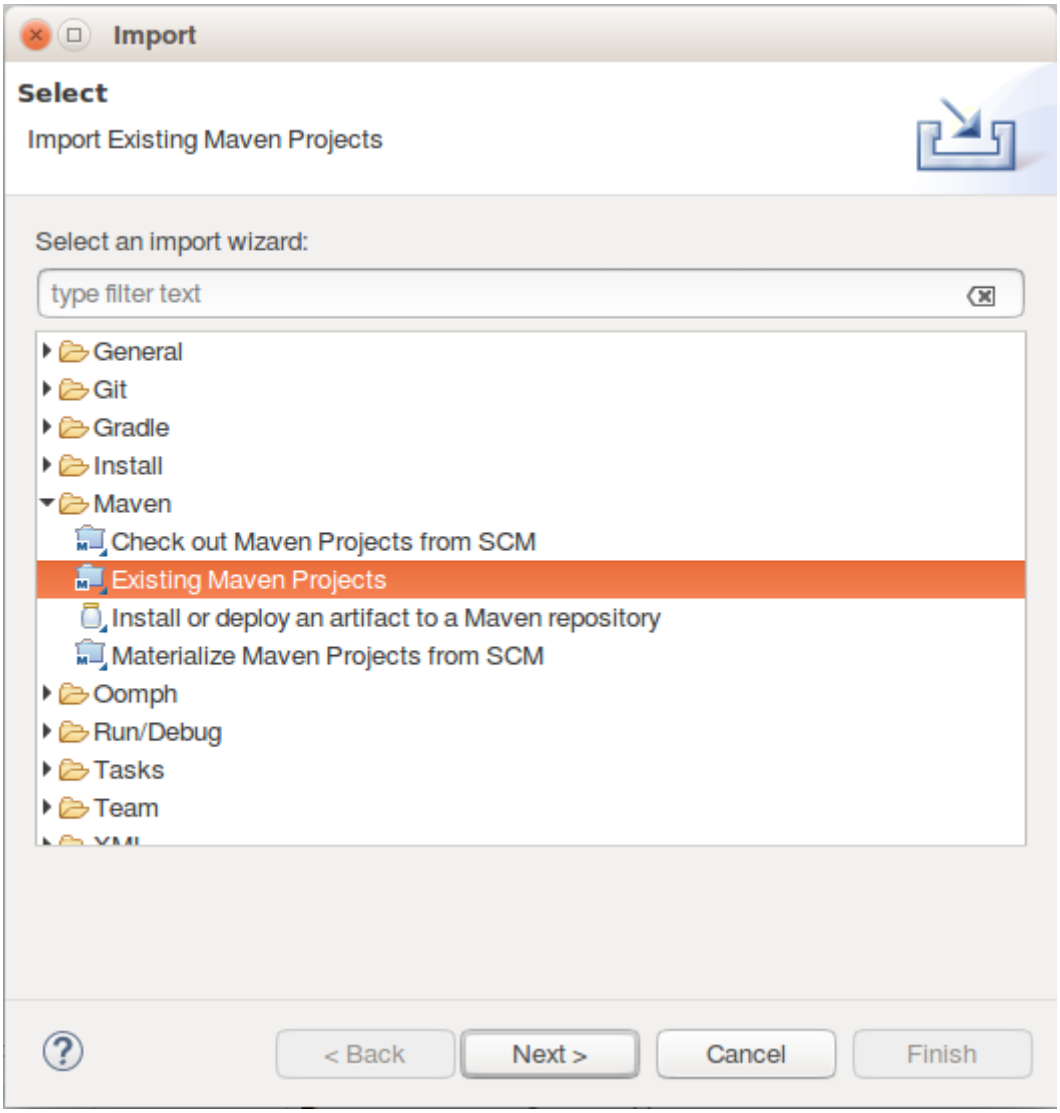


Optional Lab: Open Project in Eclipse

Once downloaded and extracted:

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

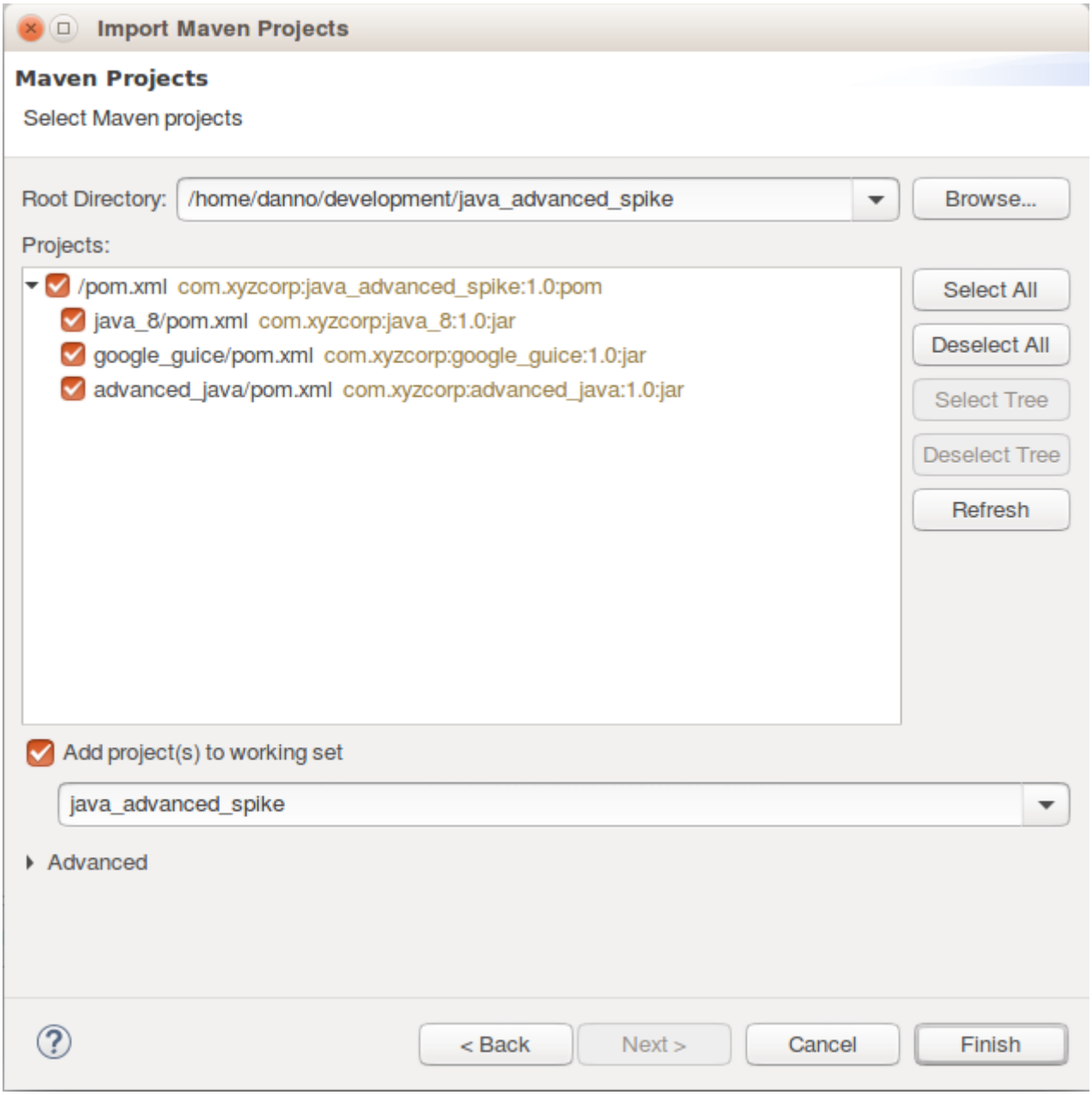
Step 2: In the following dialog box:



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

Optional Lab: Open Project in Eclipse (Continued)

Step 3:



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

Step 4: Click *Finish*

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.)

Lab: Create `MyPredicate`

Step 1: Ensure you have a `src/main/java` directory in the `java_8` module

Step 2: Ensure that the folders are seen as a build path (Eclipse only)

Step 3: Create a package called `com.xyzcorp` in `src/main/java`

Step 4: Create an interface in `com.xyzcorp` called `MyPredicate`

```
package com.xyzcorp;

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

About `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.

```
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

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

Lab: Using `MyPredicate`

Step 1: Create a File in the `com.xyzcorp` package called ***Functions.java***

Step 2: Create an method called `myFilter` as seen below.

```
package com.xyzcorp;

import java.util.ArrayList;
import java.util.Arrays;
import java.util.List;

public class Functions {

    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;
    }
```

Note: This is the functional `filter`

Lab: Test Method in *LambdaTest.java*

Step 1: Ensure you have a `src/test/java` directory in the java_8 module

Step 2: Ensure that the folders are seen as a build path (Eclipse only)

Step 3: Create a package called `com.xyzcorp` in `src/test/java`

Step 4: Create a class called `LambdaTest` in the `com.xyzcorp` package with the following test:

```
package com.xyzcorp;

import org.junit.Test;

import java.util.Arrays;
import java.util.List;

public class LambdasTest {

    @Test
    public void 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);
    }
}
```

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

Step 5: Run the test in your IDE to verify that it works as expected

Lab: `MyPredicate` is "Lambdaized"

Step 1: In the test you just wrote, convert `MyPredicate` into a lambda and use your IDE's faculties to do so.

```
package com.xyzcorp;

import org.junit.Test;

import java.util.Arrays;
import java.util.List;

public class LambdasTest {

   @Test
    public void 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);
    }
}
```

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]`

Lab: Create a `MyFunction`

Step 1: Create an `interface` for `MyFunction`

- In `src/main/java` and in the package `com.xyzcorp` create an `interface` called `MyFunction`
- The interface should have a method called `apply`
- The `MyFunction` interface should have two parameterized types `T1` and `R`
- The `apply` method have one parameter `(T1 in)`
- The `apply` method should have one return type: `R`

Lab: Create a `myMap` in *Functions.java*

Step 1: Create `static` method called `myMap` in ***Functions.java*** with the following method header:

```
public static <T, R> List<R> myMap(List<T> list, MyFunction<T, R> function) { }
```

Step 2: Fill in the method with what you believe a `map` should look like given the previous description.

Lab: Use `myMap` in *LambdaTest.java*

Step 1: Add the following test to your ***LambdaTest.java*** file:

```
package com.xyzcorp;

import org.junit.Test;

import java.util.Arrays;
import java.util.List;

public class LambdasTest {

    ...

    @Test
    public void 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);
    }
}
```

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

Step 3: Run to verify it all works!

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.

Lab: Create `MyConsumer`

Step 1: Under `src/main/java`, and inside the `com.xyzcorp` package, create an `interface` called `MyConsumer` with the following content:

```
package com.xyzcorp;

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

Lab: Create a `forEach` in *ListOps.java*

Step 1: Create `static` method called `myForEach` in ***Functions.java*** with the following method header:

```
public static <T, R> void myForEach(List<T> list, MyConsumer<T> consumer) {}
```

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

Lab: Use `myForEach` in *LambdaTest.java*

Step 1: Add the following test to your ***LambdaTest.java*** file:

```
package com.xyzcorp;

import java.util.ArrayList;
import java.util.Arrays;
import java.util.List;

public class LambdaTest {

    ...

    @Test
    public void testForEach() {
        List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15, 19, 21, 33, 78, 93,
10);
        Functions.myForEach(numbers, new MyConsumer<Integer>() {
            @Override
            public void consume(Integer item) {
                System.out.println(item);
            }
        });
    }
}
```

Step 4: Convert the `new MyConsumer` anonymous instantiation into a lambda using your IDE's faculties

Step 5: Run to verify it all works!

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`

Lab: `forEach` with a method reference

Step 1: Convert `x -> System.out.println(x)` from the `testForEach` exercise in ***LambdaTest.java*** into a method reference.

```
package com.xyzcorp;

import org.junit.Test;

import java.util.Arrays;
import java.util.List;

public class LambdasTest {

    ...

    @Test
    public void testForEach() {
        List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15, 19, 21, 33, 78, 93,
10);
        Functions.myForEach(numbers, System.out::println);
    }
}
```

NOTE	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.

Lab: Method Reference to a static method

Step 1: Enter the following in the test method, `testMethodReferenceAStaticMethod` into ***LambdaTests.java*** and convert it using a method reference.

```
package com.xyzcorp;

import org.junit.Test;

import java.util.Arrays;
import java.util.List;

public class LambdasTest {

    ...

    @Test
    public void 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)));
    }
}
```

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

Step 2: Run to verify it all works!

Lab: Method Reference with a Containing Type

Step 1: Enter the following test method `testMethodReferenceAContainingType` in ***LambdasTest.java*** and convert it using a method reference.

```
package com.xyzcorp;

import org.junit.Test;

import java.util.Arrays;
import java.util.List;

public class LambdasTest {

    ...

    @Test
    public void testMethodReferenceAContainingType() {
        List<String> words = Arrays.asList("One", "Two", "Three", "Four");
        System.out.println(Functions.myMap(words, s -> s.length()));
    }
}
```

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

Step 2: Run to verify it all works!

Lab: Method Reference with a Containing Type Trick Question

Step 1: Enter the following test method `testMethodReferenceAContainingTypeTrickQuestion` in ***LambdasTest.java*** and convert it using a method reference.

```
package com.xyzcorp;

import org.junit.Test;

import java.util.Arrays;
import java.util.List;

public class LambdasTest {

    ...

    @Test
    public void testMethodReferenceAContainingTypeTrickQuestion() {
        List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15, 19, 21, 33, 78, 93,
10);
        System.out.println(Functions.myMap(numbers, number -> number.toString()));
    }
}
```

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

Step 2: Run to verify it all works!

Lab: Create a `Tax Rate` class:

Step 1: In `src/main/java`, create a file called ***TaxRate.java*** in the `com.xyzcorp` package with the following content:

```
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;
    }
}
```

Step 2: Ensure it compiles.

Lab: Method Reference with an Instance

Step 1: Enter the following test method `testMethodReferenceAnInstance` in ***LambdasTest.java*** and convert it using a method reference.

```
package com.xyzcorp;

import org.junit.Test;

import java.util.Arrays;
import java.util.List;

public class LambdasTest {

    ...

    @Test
    public void 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)));
    }
}
```

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

Step 2: Run to verify it all works!

Lab: Method Reference with an New Type

Step 1: Enter the following test method `testMethodReferenceANewType` in ***LambdasTest.java*** and convert it using a method reference.

```
package com.xyzcorp;

import org.junit.Test;

import java.util.Arrays;
import java.util.List;

public class LambdasTest {

    ...

    @Test
    public void testMethodReferenceANewType() {
        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)));
    }
}
```

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

Step 2: Run to verify it all works!

Lab: 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();
}
```

NOTE Compare the difference to `MyConsumer`

Lab: 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

Lab: Use `myGenerate` in *LambdaTest.java*

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

```
package com.xyzcorp;

import org.junit.Test;

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

public class LambdasTest {

    ...

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

NOTE	`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!

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

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

Lab: Multi-line Lambdas

Step 1: In ***LambdasTest.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 LambdasTest {

    ...

    @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();
    }
}
```

NOTE	`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));
}
```

Lab: Create Duplicated Code

An application for a closure is to avoid repetition.

Step 1: In ***LambdasTest.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 LambdasTest {

    ...

    @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.

Lab: Refactor Duplicated Code with a Closure

An application for a closure is to avoid repetition.

Step 1: In ***LambdasTest.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 LambdasTest {

    ...

    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.

Optional

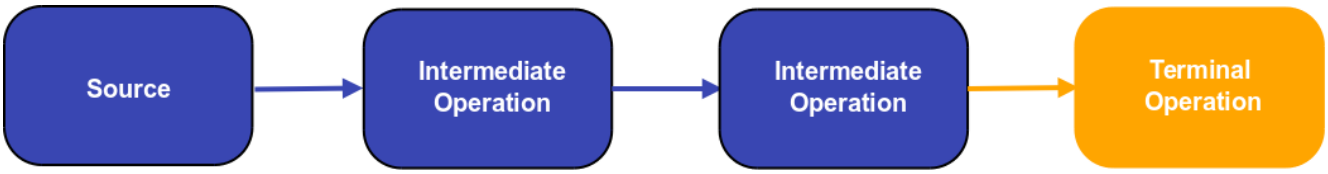
Streams

`Streams` differ from Collections in the following ways:

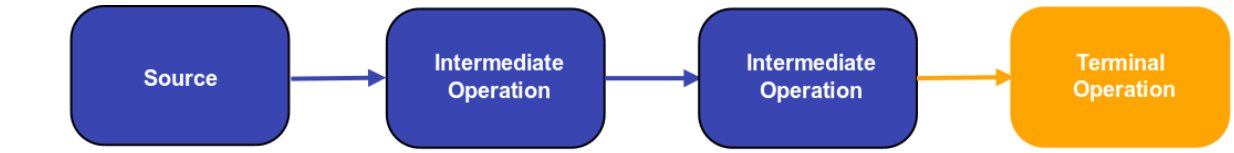
- No storage. A stream is not a data structure that stores elements; instead
- It conveys elements from a source through a pipeline of computational operations
- Sources can include.
    - Data structure
    - An array
    - Generator function
    - I/O channel
- Functional in nature. An operation on 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




```
Arrays.asList(1,2,3,4).stream()  .map(x -> x + 1)     .filter(x -> x % 2 == 0)  .collect(Collectors.toList());
```

Default Method

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

Thank You

- Email: dhinojosa@evolutionnext.com
- Github: https://www.github.com/dhinojosa
- Twitter: http://twitter.com/dhinojosa
- Google Plus: http://gplus.to/dhinojosa
- Linked In: http://www.linkedin.com/in/dhevolutionnext