LAMBDA
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What's New in Java 8

Introduction to Lambda Expression in Java 8

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What You Will Learn

- The most useful new parts of Java 8
- Lambda expressions
- ~~The Stream API and Collectors~~
- ~~And many bits and pieces~~
- ~~Java FX~~
- ~~Nashorn~~

Course Overview

- Java 8 lambda expressions and Interfaces
- ~~Stream API and Collectors~~
- ~~Date and Time API~~
- ~~Strings, I/O and other bits and pieces~~
- ~~Rich interfaces: Java FX~~
- ~~Nashorn, a new Javascript engine for the JVM~~

Targeted Audience

- This is a Java course
- Basic knowledge of the main APIs
- Generics
- Collection API
- Java I/O

Module Outline

- Introduction to the « Lambda expressions »

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- The lambda syntax

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- Constructor references

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- Introduction to the « Lambda expressions »
- The lambda syntax
- Functional interfaces
- Method references
- Constructor references
- How to process data from the Collection API?

What Is a Lambda Expression for?

- A simple example

```
public interface FileFilter {

   boolean accept(File file) ;
}
```

What Is a Lambda Expression for?

- Let's implement this interface

```
public class JavaFileFilter implements FileFilter {

   public boolean accept(File file) {
      return file.getName().endsWith(".java") ;
   }
}
```

What Is a Lambda Expression for?

- Let's implement this interface

```
public class JavaFileFilter implements FileFilter {

   public boolean accept(File file) {
      return file.getName().endsWith(".java");
   }
}
```

- And use it:

```
JavaFileFilter fileFilter = new JavaFileFilter();
File dir = new File("d:/tmp");
File[] javaFiles = dir.listFiles(fileFilter);
```

What Is a Lambda Expression for?

- Let's use an anonymous class

```
FileFilter fileFilter = new FileFilter() {

   @Override
   public boolean accept(File file) {
      return file.getName().endsWith(".java");
   }
};

File dir = new File("d:/tmp");
File[] javaFiles = dir.listFiles(fileFilter);
```

Anonymous Inner Class

What Is a Lambda Expression for?

- **The first answer is :**

  To make instances of anonymous classes easier to write

What Is a Lambda Expression for?

- **The first answer is :**

To make instances of anonymous classes easier to write and read!

A First Lambda Expression

- Let's use an anonymous class

```
FileFilter fileFilter = new FileFilter() {

   @Override
   public boolean accept(File file) {
      return file.getName().endsWith(".java");
   }
};
```

A First Lambda Expression

- Let's use an anonymous class

```
FileFilter fileFilter = new FileFilter() {

    @Override
    public boolean accept(File file) {
        return file.getName().endsWith(".java");
    }
};
```

We take the parameters

```
FileFilter filter = (File file)
```

A First Lambda Expression

- Let's use an anonymous class

```
FileFilter fileFilter = new FileFilter() {

   @Override
   public boolean accept(File file) {
      return file.getName().endsWith(".java");
   }
};
```

and then…

```
FileFilter filter = (File file) ->
```

A First Lambda Expression

- Let's use an anonymous class

```
FileFilter fileFilter = new FileFilter() {

    @Override
    public boolean accept(File file) {
        return file.getName().endsWith(".java");
    }
};
```

return this

```
FileFilter filter = (File file) -> file.getName().endsWith(".java");
```

A First Lambda Expression

- Let's use an anonymous class

```
FileFilter fileFilter = new FileFilter() {

   @Override
   public boolean accept(File file) {
      return file.getName().endsWith(".java");
   }
};
```

- This is a Java 8 lambda expression:

```
FileFilter filter = (File file) -> file.getName().endsWith(".java");
```

So What Is a Java 8 Lambda Expression?

- Answer: another way of writing instances of anonymous classes

- **Live coding : FileFilter, Runnable, Comparator**

Several Ways of Writing a Lambda Expression

- The simplest way:

```
FileFilter filter = (File file) -> file.getName().endsWith(".java");
```

Several Ways of Writing a Lambda Expression

- The simplest way:

```
FileFilter filter = (File file) -> file.getName().endsWith(".java");
```

- If I have more than one line of code:

```
Runnable r = () -> {
    for (int i = 0; i < 5; i++) {
        System.out.println("Hello world!");
    }
};
```

Several Ways of Writing a Lambda Expression

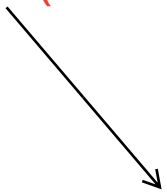
- **If I have more than one argument:**

```
Comparator<String> c =
   (String s1, String s2) ->
      Integer.compare(s1.length(), s2.length());
```

```
Comparator<String> comp = new Comparator<String>() {

   @Override
   public int compare(String s1, String s2) {

      return Integer.compare(s1.length(), s2.length());
   }
};
```



Example of Anonymous Inner Class

Three Questions About Lambdas

- What is the type of a lambda expression?

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- Can a lambda be put in a variable?

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- What is the type of a lambda expression?
- Can a lambda be put in a variable?
- Is a lambda expression an object?

What Is the Type of a Lambda Expression?

- Answer: a functional interface

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- What is a functional interface?

Functional Interface

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```
public interface Runnable {

    run();
};
```

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- Example:

```
public interface Runnable {

    run();
};
```

```
public interface Comparator<T> {

    int compareTo(T t1, T t2);
};
```

Functional Interface

- A functional interface is an interface with only one *abstract* method
- Example:

```
public interface Runnable {

   run();
};
```

```
public interface Comparator<T> {

   int compareTo(T t1, T t2);
};
```

```
public interface FileFilter {

   boolean accept(File pathname);
};
```

Functional Interface

- A functional interface is an interface with only one *abstract* method
- Methods from the Object class don't count:

```
public interface MyFunctionalInterface {

    someMethod();

    /**
     * Some more documentation
     */
    equals(Object o);
};
```

Some methods of the object class sometimes are added to an interface. We could think that it doesn't make any sense, because all the objects in Java are extending the object class, so they all provide the methods from the object class, naturally. Now, most of the time, when someone declares a method from the object class in an interface, it is usually to define some documentation to give a special semantic to this method, and to add some Java doc that might be different than the Java doc from the object's class.So those methods don't count in the count of abstract methods to tell if an interface is functional or not.

Functional Interface

- A functional interface can be annotated

```
@FunctionalInterface
public interface MyFunctionalInterface {

    someMethod();

    /**
     * Some more documentation
     */
    equals(Object o);
};
```

- It is just here for convenience, the compiler can tell me whether the interface is functional or not

Three Questions About Lambdas

- **What is the type of a lambda expression?**
  - Answer: a functional interface
- **Can a lambda be put in a variable?**
- **Is a lambda expression an object?**

Can I Put a Lambda Expression in a Variable?

- Answer is yes!

This is the variable

```
Comparator<String> c =
   (String s1, String s2) ->
      Integer.compare(s1.length(), s2.length());
```

Can I Put a Lambda Expression in a Variable?

- Answer is yes!

```
Comparator<String> c =
   (String s1, String s2) ->
      Integer.compare(s1.length(), s2.length());
```

- Consequences: a lambda can be taken as a method parameter, and can be returned by a method

Three Questions About Lambdas

- **What is the type of a lambda expression?**
  - Answer: a functional interface
- **Can a lambda be put in a variable?**
  - Answer: yes!
- **Is a lambda expression an object?**

Is a Lambda an Object?

- This question is tougher than it seems…

Is a Lambda an Object?

- Let's compare the following:

```
Comparator<String> c =
   (String s1, String s2) ->
      Integer.compare(s1.length(), s2.length());
```

```
Comparator<String> c =
   new Comparator<String>(String s1, String s2) {

      public boolean compareTo(String s1, String s2) {
         Integer.compare(s1.length(), s2.length());
      }
   };
```

Is a Lambda an Object?

- Let's compare the following:

```
Comparator<String> c =
   (String s1, String s2) ->
      Integer.compare(s1.length(), s2.length());
```

```
Comparator<String> c =
   new Comparator<String>(String s1, String s2) {

      public boolean compareTo(String s1, String s2) {
         Integer.compare(s1.length(), s2.length());
      }
   };
```

- A lambda expression is created without using « new »

Three Questions About Lambdas

- **What is the type of a lambda expression?**
  - Answer: a functional interface
- **Can a lambda be put in a variable?**
  - Answer: yes!
- **Is a lambda expression an object?**
  - The answer is complex, but no

The first one is a lambda expression; the second one is an instance of an anonymous class. What the biggest difference is that the instance of the anonymous class is created using the keyword new, so I am explicitly asking the JVM to create a new object in this case, and creating a new object is not free. When I create a new object, I need to get some memory. I need to clean up that memory, then execute it, static initializers, then execute the static blocks, and then, the non-static initializers, and then, the non-static blocks, and once all of this is done, I need to execute the constructor from the object class and from all the inheritance hierarchy from the object class to the class I'm instancing. So, all this process can be quite heavy. At least, it's an overhead, and I don't have to pay this overhead when I'm creating a lambda expression.

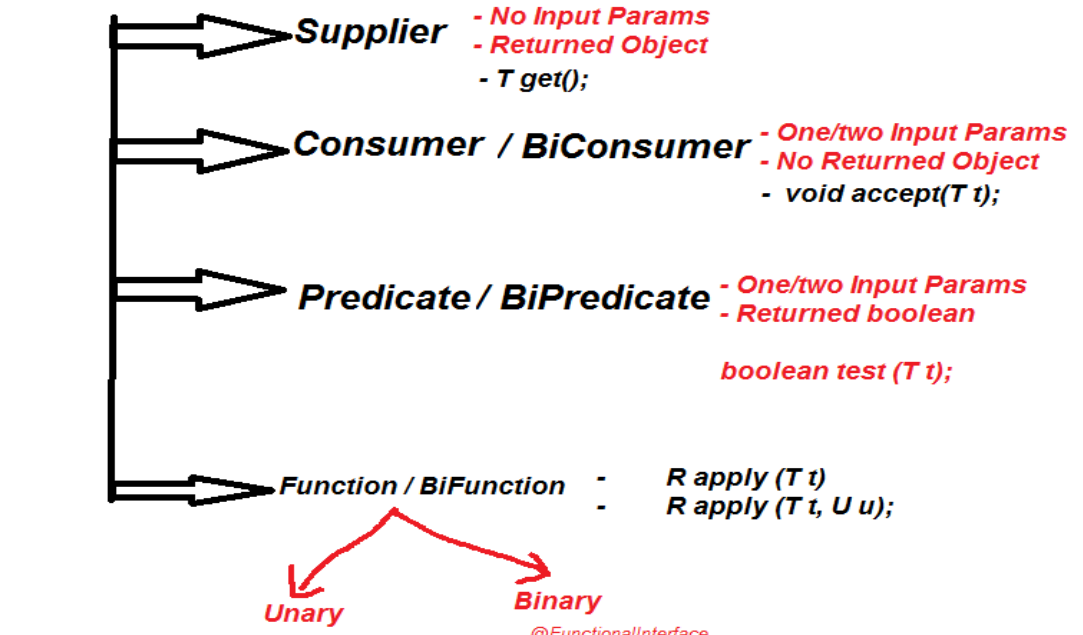
Three Questions About Lambdas

- **What is the type of a lambda expression?**
  - Answer: a functional interface
- **Can a lambda be put in a variable?**
  - Answer: yes!
- **Is a lambda expression an object?**
  - The answer is complex, but no
  - Exact answer: a lambda is an object without an identity

And, in fact, yes, the Java Virtual Machine does not create a new object every time I use a lambda expression, so it is much less work for the JVM to use lambda expression, and the performances are much better, when I execute code in lambda expressions than when they are declared in instances of anonymous classes. Note that, a lambda expression is still recording an object inside the JVM. It is an object of a new kind in Java 8. It is called an object without its own identity.

Functional Interfaces Toolbox

- New package : java.util.function
- With a rich set of functional interfaces



Package java.util.function

- 4 categories:
- Supplier

```
@FunctionalInterface
public interface Supplier<T> {

    T get();
}
```

Input Params: No
Object Returned: Yes

Package java.util.function

- 4 categories:
- Consumer

```
@FunctionalInterface
public interface Consumer<T> {

   void accept(T t);
}
```

✓ Input Params: Yes
Object Returned: No

Package java.util.function

- 4 categories:
- Consumer / BiConsumer

```
@FunctionalInterface
public interface Consumer<T> {

   void accept(T t);
}
```

```
@FunctionalInterface
public interface BiConsumer<T, U> {

   void accept(T t, U u);
}
```

Two Input parameters

Package java.util.function

- 4 categories:
- Predicate

```
@FunctionalInterface
public interface Predicate<T> {

   boolean test(T t);
}
```

Input Params: Yes
Object Returned: Boolean

Package java.util.function

- 4 categories:
- Predicate / BiPredicate

```
@FunctionalInterface
public interface Predicate<T> {

    boolean test(T t);
}
```

```
@FunctionalInterface
public interface BiPredicate<T, U> {

    boolean test(T t, U u);
}
```

Package java.util.function

- 4 categories:
- Function

```
@FunctionalInterface
public interface Function<T, R> {

   R apply (T t);
}
```

Input Params: Yes
Object Returned: Yes

Package java.util.function

- 4 categories:
- Function / BiFunction

```
@FunctionalInterface
public interface Function<T, R> {

   R apply (T t);
}
```

```
@FunctionalInterface
public interface BiFunction<T, U, R> {

   R apply (T t, U u);
}
```

Package java.util.function

- 4 categories:
- Function / UnaryOperator

```
@FunctionalInterface
public interface Function<T, R> {

   R apply (T t);
}
```

```
@FunctionalInterface
public interface UnaryOperator<T> extends Function<T, T> {
}
```

Package java.util.function

- 4 categories:
- BiFunction / BinaryOperator

```
@FunctionalInterface
public interface Function<T, U, R> {

   R apply (T t, U u);
}
```

```
@FunctionalInterface
public interface BinaryOperator<T> extends BiFunction<T, T, T> {
}
```

More Lambda Expressions Syntax

- Most of the time, parameter types can be omitted

```
Comparator<String> c =
   (String s1, String s2) ->
      Integer.compare(s1.length(), s2.length());
```

- Becomes:

```
Comparator<String> c =
   (s1, s2) ->
      Integer.compare(s1.length(), s2.length());
```

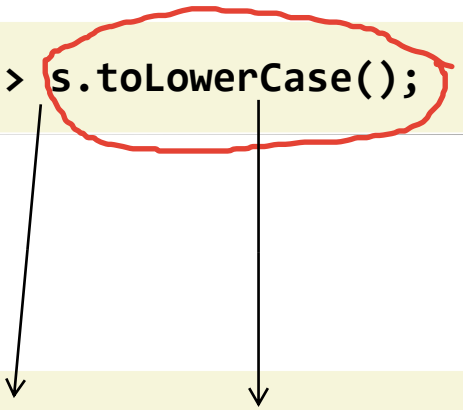
Method References

- This lambda expression:

```
Function<String, String> f = s -> s.toLowerCase();
```

- Can be written like that:

```
Function<String , String> f = String::toLowerCase;
```



Method References

- This lambda expression:

```
Consumer<String> c = s -> System.out.println(s);
```

- Can be written like that:

```
Consumer<String> c = System.out::println;
```

Method References

- This lambda expression:

```
Comparator<Integer> c = (i1, i2) -> Integer.compare(i1, i2);
```

- Can be written like that:

```
Comparator<Integer> c = Integer::compare;
```

So What Do We Have so Far?

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- A new interface concept: the « functional interface »

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- A new concept: the « lambda expression », with a new syntax
- A new interface concept: the « functional interface »

- Question: how can we use this to process data?

How Do We Process Data in Java?

- Where are our objects?

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- Most of the time: in a Collection (or maybe a List, a Set or a Map)

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- Most of the time: in a Collection (or maybe a List, a Set or a Map)
- Can I process this data with lambdas?

```
List<Customer> list = ...;
list.forEach(customer -> System.out.println(customer));
```

How Do We Process Data in Java?

- Where are our objects?
- Most of the time: in a Collection (or maybe a List, a Set or a Map)
- Can I process this data with lambdas?

```
List<Customer> list = ...;
list.forEach(customer -> System.out.println(customer));
```

- Or:

```
List<Customer> list = ...;
list.forEach(System.out::println);
```

Can I Process This Data with Lambdas?

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```
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```
List<Customer> list = ...;
list.forEach(System.out::println);
```

- But… where does this forEach method come from?

Can I Process This Data with Lambdas?

- The good news is: yes!
- We can write:

```
List<Customer> list = ...;
list.forEach(System.out::println);
```

- But… where does this forEach method come from?
- Adding a forEach method on the Collection interface breaks the compatibility: all the implementations have to be refactored!

How to Add Methods to Iterable?

- Without breaking all the existing implementations?

```
public interface Iterable<E> {

    // the usual methods

    void forEach(Consumer<E> consumer);
}
```

How to Add Methods to Iterable?

- Without breaking all the existing implementations?

```
public interface Iterable<E> {

   // the usual methods

   void forEach(Consumer<E> consumer);
}
```

- Refactoring these implementations is not an option

How to Add Methods to Iterable?

- If we cant put the implementation in ArrayList, then…

```
public interface Iterable<E> {

   // the usual methods

   default void forEach(Consumer<E> consumer) {

      for (E e : this) {
         consumer.accept(e);
      }
   }
}
```

Default Methods

- This is a new Java 8 concept
- It allows to change the old interfaces without breaking the existing implementations

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- And by the way…
- Static methods are also allowed in Java 8 interfaces!

Examples Of New Patterns

- Predicates

```
Predicate<String> p1 = s -> s.length() < 20;
Predicate<String> p2 = s -> s.length() > 10;
```

Examples Of New Patterns

- Predicates

```
Predicate<String> p1 = s -> s.length() < 20;
Predicate<String> p2 = s -> s.length() > 10;

Predicate<String> p3 = p1.and(p2);
```

Examples Of New Patterns

- Predicates

```
Predicate<String> p1 = s -> s.length() < 20;
Predicate<String> p2 = s -> s.length() > 10;

Predicate<String> p3 = p1.and(p2);
```

```
@FunctionalInterface
public interface Predicate<T> {

   boolean test(T t);

   default Predicate<T> and(Predicate<? super T> other) {
      Objects.requireNonNull(other);
      return (t) -> test(t) && other.test(t);
   }
}
```

Examples Of New Patterns

- Predicates

```
Predicate<String> id = Predicate.isEqual(target);
```

Examples Of New Patterns

- Predicates

```
Predicate<String> id = Predicate.isEqual(target);
```

```
@FunctionalInterface
public interface Predicate<T> {

   boolean test(T t);

   static <T> Predicate<T> isEqual(Object targetRef) {
      return (null == targetRef)
             ? Objects::isNull
             : object -> targetRef.equals(object);
   }
}
```

Summary

- The new « lambda expression » syntax
- A lambda expression has a type : a functional interface
- Definition of a functional interface, examples
- Method and constructor references
- Iterable.forEach method
- Default and static methods in interfaces, examples