Are Lambdas Great in Java 8?

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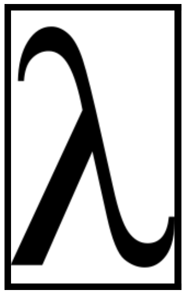


Topics

- Lambda expressions
- Functional interfaces
- Default methods
- Stream
- Library support

Schedule

Schedule adopted in April 2013

- Java 7 launched July 7, 2011
- M8 - Sep 5 - Developer Preview
- M9 - Jan 23 - Final Release Candidate
- GA - Mar 18 - General Availability

http://openjdk.java.net/projects/jdk8/

Java 8 Features

- Lambdas
- java.time (Joda Time)
- Nashorn JavaScript Engine
- Additions to:
    - Collections
    - Concurrency
    - IO and Native IO
    - Reflection and annotations

- http://openjdk.java.net/projects/jdk8/features
- http://www.techempower.com/blog/2013/03/26/everything-about-java-8/

What’s a Lambda?

Λλ

- Greek letter
- Alonzo Church discovered lambda calculus in 30s
- multiply = `λxy.x*y`
- true = `λxy.x`

Background

- Productivity = Reuse
  - Combine smaller units
  - Avoid mutation
- Problems:
  - Java is object oriented
  - Encapsulation and mutation
  - Classes are heavyweight

Avoid Mutation

```java
class Cafe {
    // mutation
    Coffee buyCoffee(CreditCard cc, Payments p) {
        Coffee cup = new Coffee();
        p.charge(cc, cup.getPrice());
        return cup;
    }

    // referentially transparent
    P2<Coffee, Charge> buyCoffee2(CreditCard cc) {
        Coffee cup = new Coffee()
        return P.p(cup, new Charge(cc, cup.getPrice()));
    }
}
```

Lambda Rationale

- Concise function syntax
- Higher order functions for collections
- Sequential and parallel operations
- Move towards functional programming

Function Brevity

```
// Java 7
execute(new Runnable(){
    public void run() {
        processImage(image);
    }
});
button.addActionListener(new ActionListener(){
    @Override
    public void actionPerformed(ActionEvent event) {
        setBackground(Color.GREEN);
    }
});
// Java 8
execute(() -> processImage(image));
button.addActionListener(e -> setBackground(Color.GREEN));)
```

Function Brevity

```
// Sort strings by length, Java 7
Arrays.sort(array, new Comparator<String>() {
    @Override
    public int compare(String s1, String, s2) {
        return s1.length() - s2.length();
    }
}

// Java 8
Arrays.sort(array, (s1, s2) -> s1.length() - s2.length());
```

Function Brevity

```
// Collection.forEach
void forEach(Consumer<? super T> c) { ... }

interface Consumer<T> { void accept(T t); }

// Java 7
pointList.forEach(new Consumer<Point>() {
    public void accept(Point p) {
        p.move(p.y, p.x);
    }
});

// Java 8
pointList.forEach(p -> p.move(p.y, p.x));
```

Lambda Expressions

- (parameters) -> expression
- (parameters) -> { statements; }

```
(int x) -> 2 * x
x -> 2 * x
(int x, int y) -> x + y
(x, y) -> x + y
() -> 42
c -> {
    int s = c.size();
    c.clear();
    return s;
}
```

Functional Interfaces

- Interface with one abstract method
- Generally, call with a lambda
- public void forEach(Consumer consumer);
- Sometimes called SAM - Single Abstract Method
- Enforced with @FunctionalInterface
- Runnable, Callable, Comparator, etc.

Function Package

```
// java.util.function

Function<A, B> // transform A to B
Predicate<T> // boolean testing, Function<T, Boolean>
Consumer<T> // perform actions, Function<T, Void>
Supplier<T> // provide T, Function<Void, T>
UnaryOperator<T> // Function<T, T>

BiFunction<A, B, C>
BinaryOperator<T> // BiFunction<T, T, T>
// and others...
```

Lambda Typing

- Type depends on context
- Type of: x -> 2 * x ?
- Target typing

```
ActionListener l = (ActionEvent e) -> ui.dazzle(e.getModifiers());
ActionListener l = e -> ui.dazzle(e.getModifiers());

interface IntOperation { int operate(int i); }
IntOperation iop = x -> x + 2
interface DoubleOperation { int operate(int i); }
DoubleOperation dop = x -> x + 2
```

The Story So Far

Sorting a list of people by surname

```
// Java 7
List<Person> people = ...
Collections.sort(people, new Comparator<Person>() {
    public int compare(Person x, Person y) {
        return x.getLastName().compareTo(y.getLastName());
    }
});

// Java 8
Collections.sort(people, Comparator.comparing(p -> p.getLastName()));
sort(people, comparing(Person::getLastName));
```

Interface Changes

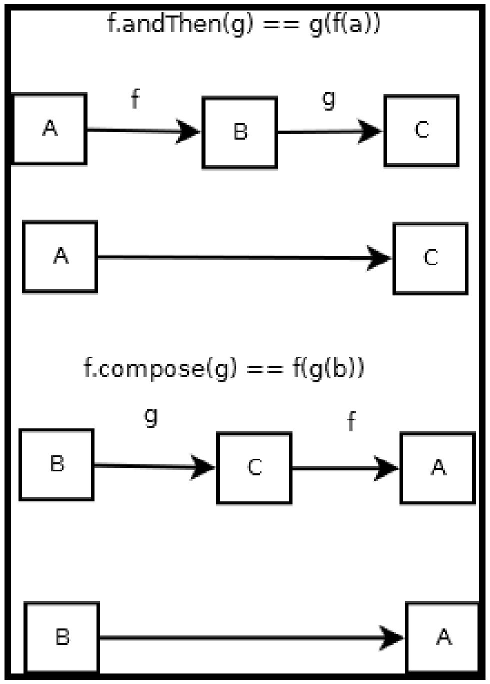
- Default methods
- Static methods
- Allows interface evolution
- Multiple inheritance without state
- Collection: forEach, stream, parallelStream, removeIf, spliterator

Function

```
package java.util.function;

@FunctionalInterface
public interface Function <T, R>  {
    R apply(T t);
    default <V> Function<T,V> andThen(Function<? super R,? extends V> after) {
        return (T t) -> after.apply(apply(t));
    }
    default <V> Function<V,R> compose(Function<? super V,? extends T> before) {
         return (V v) -> apply(before.apply(v));
    }
    static default <T> Function<T,T> identity() {
         return t -> t;
    }
}
```

Function Composition



Function Usage

```
@Test
public void testAndThen() {
    Function<Integer, Integer> f = i -> i + 1;
    assertTrue(f.andThen(j -> j * 2).apply(2) == 6);
}
```

Interface Conflicts

- Same method twice
- Rules:
  - Classes win
  - Most specific default
  - May need to resolve manually

Conflict

```
public interface A {
    default void hello() { System.out.println("Hello World from A"); }
}

public interface B {
    default void hello() { System.out.println("Hello World from B"); }
}

public class C implements A, B {

}

// Error: class C inherits unrelated defaults for hello() from
// types A and B reference to hello is ambiguous,
// both method hello() in A and method hello() in B match.
```

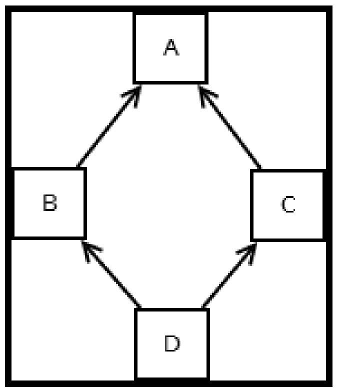
Resolution

```java
public interface A {
    default void hello() { System.out.println("Hello World from A"); }
}

public interface B {
    default void hello() { System.out.println("Hello World from B"); }
}

public class C implements A, B {
    public void hello() {
        A.super.hello();
    }
}
```

Diamond Problem



Streams

- Parallelisable sequences
- Common higher order functions: filter, map, fold(reduce/collect)
- Explicit conversions from Collection to Stream
- Streams are   Streams: co-inductive, lazy, potentially infinite lists

```
shapes.stream()
    .filter(s -> s.getColor() == BLUE)
    .forEach(s -> s.setColor(RED));
List<Shape> blue = shapes.stream()
    .filter(s -> s.getColor() == BLUE)
    .collect(Collectors.toList());
Set<Box> hasBlueShape = shapes.stream()
    .filter(s -> s.getColor() == BLUE)
    .map(s -> s.getContainingBox())
    .collect(Collectors.toSet());
```

Parallelism

- Stream sequential by default
- Avoid mutating values
- Explicit parallelism

```
int sum = shapes.parallelStream()
    .filter(s -> s.getColor() == BLUE)
    .mapToInt(s -> s.getWeight())
    .sum();
```

Core Stream Methods

```
// forEach(Consumer)
employees.stream().forEach(e -> e.setSalary(e.getSalary() * 1.1);

// map(Function)
ids.stream().map(EmployeeUtils::findEmployeeById)

// filter(Predicate)
employees.stream().filter(e -> e.getSalary() > 5000);

// findFirst()
employees.stream().filter(...).findFirst().orElse(GOTO_EMPLOYEE);

// reduce(initialValue, BinaryOperator)
nums.stream().reduce(Double.MIN_VALUE, Double::max)
```

Stream (vs Collections)

- Don't store values
- Nature is functional
- Usually lazy
- Potentially infinite

Separate Stream?

- Early versions had methods on Collection and Iterable
- Confusion in mutation vs functional
- Lazy vs eager mode
- Name collisions with Collection
- Tranformation needed for parallelism

Terminal Operations

- zero or more intermediate operations
- concat, distinct, filter, flatMap, limit, map, skip
- one terminal operation
- foreach, forEachOrdered, toArray, reduce, collect, min, max, count, anyMatch, allMatch, noneMatch, findFirst, findAny

Optional

- Type with zero or one value
- of, filter, flatMap, map, orElse
- Lots of imperative methods too

```
Optional<Shape> firstBlue = shapes.stream()
    .filter(s -> s.getColor() == BLUE)
    .findFirst();
```

Java 7 Example

Find the names of albums that have at least one track rated four or higher, sorted by name.

```
 List<Album> favs = new ArrayList<>();
 for (Album a : albums) {
     boolean hasFavorite = false;
     for (Track t : a.tracks) {
         if (t.rating >= 4) {
             hasFavorite = true;
             break;
         }
     }
     if (hasFavorite) { favs.add(a); }
}
Collections.sort(favs, new Comparator<Album>() {
     public int compare(Album a1, Album a2) {
         return a1.name.compareTo(a2.name);
}});
```

Java 8 Example

Find the names of albums that have at least one track rated four or higher, sorted by name.

```
List<Album> sortedFavs = albums.stream()
    .filter(a -> a.tracks.stream().anyMatch(t -> (t.rating >= 4)))
    .sorted(Comparator.comparing(a -> a.name))
    .collect(Collectors.toList());
```

Miscellaneous

1. Lexical Scoping
2. Variable Capture
3. Method references (constructor, instance, static)
4. Lambdas are objects

Where's my Monad?

- Lots of flatMap, but no monads
- unit: a -> M a
- flatMap: M a -> (a -> M b) -> M b
- No abstraction over unit
- Re-implementation

Adding Type Constructor Parameterization to Java, http://www.jot.fm/issues/issue_2008_06/article2.pdf

```
// Warning: invalid Java
public interface Monad<M<A>> {
    M<A> unit(A a);
    <B> M<B> flatMap(M<A> ma, F<A, M<B>> f);
}
```

Functional Libraries

- Functional Java
- Totally Lazy
- Google Guava

Functional Java

- Immutable: lists, lazy list, set
- Function arities 1 to 8
- Sum types: Option, Either, Validation
- Product types 1 to 8
- Quickcheck specification based testing

Functional Groovy

- Simple Lenses
- Reader, Writer and State monads
- IO type
- Monad library
- Monad comprehensions
- Y Combinator

Next Steps

- Brisbane Functional Programming Group
- Investigate FunctionalJava
- Learn Haskell or Scala
- Books:
    - Learn You A Haskell for Great Good
    - Functional Programming in Scala

Summary

- Lambda expressions
- Functional interfaces
- Default methods
- Stream
- Library support

References

- Project Lambda - openjdk.java.net/projects/lambda
- Lambda FAQ - www.lambdafaq.org
- Everything about Java 8 - www.techempower.com/blog/2013/03/26/everything-about-java-8/
- Lambda: A peek under the hood - http://www.parleys.com/play/5251c164e4b0a43ac1212459/abou
- Stream in Top Gear - http://parleys.com/play/5251c7d6e4b0a43ac121245b/about
- Lots of Java One videos!

Thank You