

Lambda Expressions

CS 272 Software Development

Motivation



Avoid Naming Single Use Variables

1. `Map<String, Set<String>> elements = ...`
- 2.
3. `Set<String> set = elements.get("hello");`
4. `set.add("world");`
- 5.
6. `elements.get("hello").add("world");`



Avoid Naming Single Use Classes

```
1. PathMatcher matcher = new PathMatcher() {  
2.     @Override  
3.     public boolean matches(Path path) {  
4.         return path.toString().endsWith(".txt");  
5.     }  
6. };
```

<https://www.cs.usfca.edu/~cs272/javadoc/api/java.base/java/nio/file/PathMatcher.html>



Anonymous Classes

- Allows the **declaration** (i.e. superclass/interface), **definition** (i.e. method implementation), and **instantiation** (i.e. constructor call) of a class
- Always an inner class
- Never an abstract, static, or final* class

<https://docs.oracle.com/javase/specs/jls/se17/html/jls-15.html#jls-15.9.5>



Anonymous Methods?

- Many interfaces only have one abstract method
 - `PathMatcher`, `Comparator`, `Runnable`, etc.
- Is there shortcut syntax for defining these methods?
 - e.g. array initialization, auto boxing/unboxing, ...
- What does it mean for a method versus a class to be anonymous?

<https://www.cs.usfca.edu/~cs272/javadoc/api/java.base/java/lang/FunctionalInterface.html>



Brief History



Lambda Calculus

- Name comes from symbol $\Lambda \lambda$ (upper/lower lambda)
- Invented in 1930s by Alonzo Church (1903–1995)
- Can simulate any Turing machine
- All functions are **anonymous** functions
- Computational model underlying many **functional programming** languages

https://en.wikipedia.org/wiki/Lambda_calculus



Functional Programming

- Different programming paradigm
 - Uses **expressions** (returns a value) vs **statements**
 - Avoids side effects and mutable data
 - Functions may be parameters to other functions
- Produces more concise code and easier to parallelize
- Many languages support functional programming

https://en.wikipedia.org/wiki/Functional_programming



Java Implementation



Functional Interfaces

- An **annotation** applied to interfaces with exactly one abstract method
 - Does not count default methods or overriding `public Object` methods
- Instances created with **lambda expressions**, **method references**, or traditionally (implements keyword, anonymous inner class)

<https://www.cs.usfca.edu/~cs272/javadoc/api/java.base/java/lang/FunctionalInterface.html>



Functional Interfaces

```
1. package java.nio.file;
2.
3. @FunctionalInterface
4. public interface PathMatcher {
5.     boolean matches(Path path);
6. }
```

<https://github.com/openjdk/jdk/blob/master/src/java.base/share/classes/java/nio/file/PathMatcher.java>
<https://www.cs.usfca.edu/~cs272/javadoc/api/java.base/java/lang/FunctionalInterface.html>



Package java.util.function

Functional Interface	Description	Method
Function<T,...,R>	Accepts n args and produces a result	R apply(T t, ...)
Consumer<T,...>	Accepts n args and returns no results	void accept(T t, ...)
Predicate<T,...>	Accepts n args and returns a boolean	boolean test(T t, ...)
Supplier<R>	Accepts <i>no</i> args and supplies results	R get()

<https://www.cs.usfca.edu/~cs272/javadoc/api/java.base/java/util/function/package-summary.html>



Lambda Expressions

- Compact definition of a functional interface
 - *Almost* like a shortcut syntax for anonymous inner classes of interfaces with only one abstract method
- Can be passed to other methods as parameters
- Can be considered anonymous methods (methods without a name)



Lambda Expression Syntax

(a , ...) → { statements ; ... }

- Parameters enclosed in parenthesis () if more than one comma-separated parameter
- The → arrow token (a - dash and > greater than sign)
- The body enclosed in curly { } braces if not a return statement or multiple statements

<https://docs.oracle.com/javase/tutorial/java/javaOO/lambdaexpressions.html#syntax>



Anonymous Class Example

```
1. PathMatcher matcher = new PathMatcher() {  
2.     @Override  
3.     public boolean matches(Path path) {  
4.         return path.toString().endsWith(".txt");  
5.     }  
6. };
```

<https://www.cs.usfca.edu/~cs272/javadoc/api/java.base/java/nio/file/PathMatcher.html>




```
1. PathMatcher matcher1 = new PathMatcher() {
2.     @Override
3.     public boolean matches(Path path) {
4.         return path.toString().endsWith(".txt");
5.     }
6. };
7.
8. PathMatcher matcher2 = (Path path) → {
9.     return path.toString().endsWith(".txt");
10. };
```

<https://www.cs.usfca.edu/~cs272/javadoc/api/java.base/java/nio/file/PathMatcher.html>



Lambda Expression Example

```
1. PathMatcher m1 = (Path p) → {  
2.     return p.toString().endsWith(".txt");  
3. };  
4.  
5. PathMatcher m2 = p → p.toString().endsWith(".txt");  
6.  
7. Predicate<Path> m3 = p → p.toString().endsWith(".txt");
```

<https://www.cs.usfca.edu/~cs272/javadoc/api/java.base/java/nio/file/PathMatcher.html>



Method References

- Some lambda expressions call an existing method
 - e.g. `s → s.trim()`
- Use method references to use existing methods instead of using a lambda expression
 - e.g. `String::trim`

<https://docs.oracle.com/javase/tutorial/java/javaOO/methodreferences.html>



Method References

Reference	Pattern	Example
Constructor	ClassName::new	HashSet::new
Static method	ClassName::staticMethod	String::valueOf
Instance (arbitrary)	ClassName::instanceMethod	String::trim
Instance (particular)	instance::instanceMethod	mySet::add

<https://docs.oracle.com/javase/tutorial/java/javaOO/methodreferences.html>



Functions as Objects?

- **Lambda expressions are NOT objects!**
 - The “type” is a functional interface
 - Does not inherit from Object
 - Cannot use the `this`, `super`, or `new` keywords*
- Can only interact with “effectively final” variables outside its scope





CHANGE THE WORLD FROM HERE