Programming in Java – Lambda functions

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Agenda

Lambda functions

Functional interfaces

Method references

Variable capture

Lambda functions

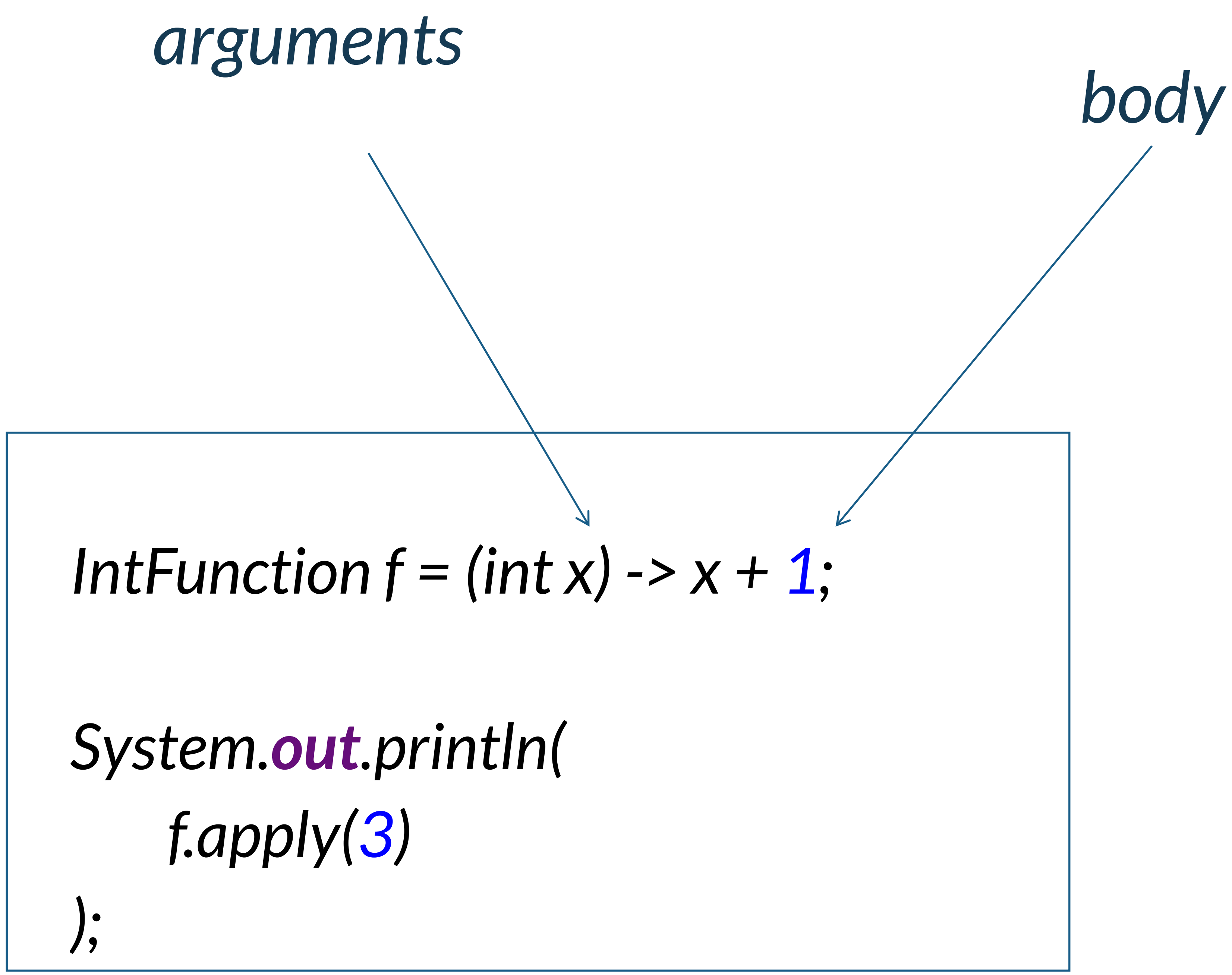
represents a functional interface

implements behavior parametrization

lambda functions

provides lazy evaluation

A first example



arguments

body

```
IntFunction f = (int x) -> x + 1;

System.out.println(
      f.apply(3)
);
```

Is really an interface?

```java
IntFunction g = new IntFunction() {
   @Override
   public Object apply(int x) {
      return x + 1;
   }
};

System.out.println(
      g.apply(3)
);
```

yes!

Are there other interfaces?

yes, many!

```
IntToDoubleFunction h = (int x) -> x * 3.1415;

System.out.println(
      h.applyAsDouble(2)
);
```

Interface definition

Note that there is a generic type in the interface definition!

```
IntFunction<String> m = (int x) -> "OK:" + x;
System.out.println(
    m.apply(3)
);
```

Interface definition

Can we define our own interface?

```
package com.esteco;
...
@FunctionalInterface
interface StringFunction<R> {
   R apply(String value);
};

...
com.esteco.StringFunction<Integer> o = (String x) -> x.length();
System.out.println(o.apply("Hello"));
```

Yes!

Simplifications

1. *Parameter types can be omitted (all or none)*
2. *a single parameter does not require parenthesis*

```
IntFunction f = x -> x + 1;
IntToDoubleFunction h = x -> x * 3.1415;
com.esteco.StringFunction<Integer> o = x -> x.length();
```

Other interfaces

Is there any general function declaration?

```
Function<Integer, String> p = x -> ":" + x + ":";
System.out.println(
      p.apply(3)
);
```

Yes!

Note that there are other method definitions!
compose(), andThen()...

Parameters

Can we use more than one parameter?

```
interface IntIntFunction<R> {
   R apply(Integer x, Integer y);
}


com.esteco.IntIntFunction q = (x, y) -> x + y;
System.out.println(
      q.apply(2, 3)
);
```

Yes, of course

Examples

Let's do it also for doubles

```
interface DoubleDoubleFunction<R> {
   R apply(Double x, Double y);
}


com.esteco.DoubleDoubleFunction<Double> r = (x, y) -> x + y;
System.out.println(
      r.apply(3.14, 0.0015)
);
```

Context dependent!

The following two lambda expressions are the same:

```
com.esteco.IntIntFunction<Integer> q = (x, y) -> x + y;

com.esteco.DoubleDoubleFunction<Double> r = (x, y) -> x + y;
```

Note that the type of the lambda expression depends on the context!

Anonymous classes

```
Thread t1 = new Thread(new Runnable() {
    @Override
    public void run() {
        System.out.println("Hi");
    }
});
t1.start();
```

Lambdas can help when using anonymous classes

can be written as:

```
Thread t2 = new Thread(() -> System.out.println("hi"));
t2.start();
```

Anonymous classes

```
JButton jb = new JButton();
jb.addActionListener(new ActionListener() {
  @Override
  public void actionPerformed(ActionEvent e) {
    System.out.println("Hi");
  }
});
```

can be written as:

```
jb.addActionListener(e -> System.out.println("Hi"));
```

Anonymous classes

anonymous classes create a new object

but there are some differences!

for example, variable capture is different

etc.

Functional interfaces

Interfaces with exactly *one* ***abstract*** *method*

```
@FunctionalInterface
interface StringFunction<R> {
    R apply(String value);
};
@FunctionalInterface
interface IntIntFunction<R> {
    R apply(Integer x, Integer y);
}
@FunctionalInterface
interface DoubleDoubleFunction<R> {
    R apply(Double x, Double y);
}
```

Functional interfaces

Predicate

BiFunction

BiPredicate

Function

many predefined

Consumer

BinaryOperator

UnaryOperator

BiConsumer

Supplier

Functional interfaces

IntFunction

LongFunction

DoubleFunction

many specialized

ToLongFunction

ToIntFunction

ToDoubleFunction

The Function functional interface

How is the Function interface defined?

```
@FunctionalInterface
public interface Function<T, R> {
  R apply(T t);
  default <V> Function<V, R> compose(...) { ... }
  default <V> Function<T, V> andThen(...) { ... }
  static <T> Function<T, T> identity() { ... }
}
```

Other methods

They can be used as in FP

```
Function<Integer, Integer> w1 = x -> x * x;
Function<Integer, Integer> w2 = x -> x + x;
System.out.println(
    w1.andThen(w2).apply(2)
);
System.out.println(
    w1.compose(w2).apply(2)
);
System.out.println(
    w1.compose(w1).compose(w2).andThen(w2).apply(2)
);
```

Other methods

```
System.out.println(
        Function.identity().apply(2)
);

System.out.println(
        ((IntFunction)(x -> x * x)).apply(2)
);
System.out.println(
        ((Function<Integer, Integer>)(x -> x * x)).apply(2)
);
```

Type information

Sometimes, type information has to be provided!

```
(x -> x*x).apply(2)   // wrong!

((Function<Integer, Integer>)(x -> x * x)).apply(2)   // OK
```

Predicate examples

```
Predicate<Integer> greaterThanZero = x -> x > 0;
Predicate<Integer> smallerThanOrEqualToZero = greaterThanZero.negate();
Predicate<Integer> smallerThanFive = x -> x < 5;
Predicate<Integer> betweenZeroAndFive = greaterThanZero.and(smallerThanFive);
Predicate<Integer> notBetweenZeroAndFive = betweenZeroAndFive.negate();

System.out.println(
    notBetweenZeroAndFive.test(6)
);
```

Method references

```
Function<String, Integer> len1 = x -> x.length();
Function<String, Integer> len2 = String::length;

System.out.println(len1.apply("Hello") + len2.apply("Hi"));
```

Method references

Can be applied to reference static and instance methods, and also to reference constructors

```
Function<String, Integer> len1 = s -> s.length();
Function<String, Integer> len2 = String::length;

BiPredicate<String, String> pred1 = (s1, s2) -> s1.equals(s2);
BiPredicate<String, String> pred2 = String::equals;

Supplier<ArrayList> c1 = () -> new ArrayList();
Supplier<ArrayList> c2 = ArrayList::new;
```

Other examples

```
static void doSomething(String s,
                        Predicate<String> p,
                        Function<String, String> f) {
  if (p.test(s))  System.out.println(f.apply(s));
}


doSomething("Numeric", x -> x.contains("m"),Function<String>.identity());
doSomething("Numeric", x -> x.contains("m"), String::toLowerCase);
doSomething("Numeric", x -> x.contains("m"), x -> "yes");
doSomething("Numeric", x -> x.length() < 5, x -> "too small");
doSomething("", String::isEmpty, x -> "empty string");
```

Variable capture

this works:

```
int a = 1;
IntFunction w = x -> x + a + 1;
System.out.println(w.apply(3));
```

this does not:

```
int a = 1;
IntFunction w = x -> x + a + 1;
a++;
System.out.println(w.apply(3));
```

Only “effectively final” variable can be captured

Example: a comparator

```
List<String> arr = Arrays.asList("Mariapia", "Teresa", "Stefano");
Collections.sort(arr, new Comparator<String>() {
   @Override
   public int compare(String o1, String o2) {
      return o1.length() - o2.length();
   }
});
```

```
Collections.sort(arr, (o1, o2) -> o1.length() - o2.length());
Collections.sort(arr, String::compareToIgnoreCase);
```

```
System.out.println( arr.stream().collect(Collectors.joining(", ")) );
```

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Thank you!

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