Fundamentals of Java



Effective programming with lambda

SESSION 15

Objectives



- Explain lambdas
- Identify the built-in functional interfaces
- Explain code refactoring for readability using lambdas
- Describe debugging of lambda





Lambda usage



- Lambda expression:
 - Introduced in Java 8
 - Unnamed blocks of code
 - Facilitate functional programming
- Types of lambda expressions are:
 - Object lambda
 - Inline lambda
- Inferred type lambdas
 - Allow passing parameters to the expression body

Lambda types [1/2]



 Code for creating different types of lambdas and using them:

```
☐ import java.util.*;
13
14
      @FunctionalInterface
      interface FunctionalA {
16
          int doWork (int a, int b);
17
18
      public class LambdaExpressionDemo {
19
          public static void main(String[] args) {
20
              /*1: Using basic lambda */
              FunctionalA a1 = (int n1, int n2) \rightarrow n1 + n2;
              System.out.println("5+5=" + a1.doWork(5, 5));
23
24
              /*2: Using lambda with inferred types */
25
              FunctionalA a2 = (n1, n2) \rightarrow n1 + n2;
              System.out.println("5+10=" + a2.doWork(5, 10));
              /*3: Using lambda with expression body containing return statement */
29
              FunctionalA a3 = (n1, n2) \rightarrow {
30
                  return n1 + n2;
31
              };
32
              System.out.println("5+15=" + a3.doWork(5, 15));
```

Lambda types [2/2]



```
33
34
              /*4: Using lambda with expression body containing multiple statements */
35
               FunctionalA a4 = (n1, n2) \rightarrow {
36
                   int sum = n1 + n2;
37
                   int result = sum * 10;
38
                   return result;
39
              };
40
               System.out.println((5+10)*10= + a4.doWork(5,10));
41
42
              /*Lambda 5: Passing lambda as method parameter to Arrays.sort() method*/
               String[] w = new String[]{"Hi", "Hello", "HelloWorld", "H"};
43
44
               System.out.println("Original array= " + Arrays.toString(w));
              Arrays.sort(w, (first, second) -> Integer.compare(first.length(), ←
45
      second.length());
                                                                Output - demo_lambda (run)
               System.out.println("Sorted array by length u
46
                                                                    run:
      toString(w));
                                                                    5+5= 10
47
                                                                    5+10= 15
                                                                    5+15= 20
                                                                    (5+10) *10= 150
                                                                    Original array= [Hi, Hello, HelloWorld, H]
                                                                    Sorted array by length using lambda= [H, Hi, Hello, HelloWorld]
                                                                    BUILD SUCCESSFUL (total time: 1 second)
```

Built-in functional interface [1/2]



Following table lists functional interfaces

Interface	Abstract Method	Description
Predicate <t></t>	boolean test(T t)	Represents an operation that checks a
		condition and returns a boolean
		value as result
Consumer <t></t>	void accept(T t)	Represents an operation that takes an
		argument but returns nothing
Function <t, r=""></t,>	R apply(T t)	Represents an operation that takes an
		argument and returns some result to
		the caller
Supplier <t></t>	T get()	Represents an operation that does not
		take any argument but returns a value to
		the caller

Built-in functional interface [2/2]



```
☐ import java.util.function.*;
13
14
     public class FunctionalInterfacesDemo {
15
            public static void main(String[] args) {
              //test Predicate
16
              Predicate<String> r1 = arg -> (arg.equals("Hello Lambda"));
17
18
              String testStr = "Hello Lambda";
19
              System.out.println(r1.test(testStr));
20
              //test Consumer
22
              Consumer < String > r2 = str -> System.out.println(str.toUpperCase());
23
              r2.accept("hello lambda");
24
                                                                                  Output - demo_lambda (run)
              //test Function
                                                                                     run:
26
              Function<String, Integer> r3 = str -> str.length();
                                                                                     true
              System.out.println(r3.apply("Hello Lambda"));
                                                                                     HELLO LAMBDA
                                                                                     12
29
              //test Supplier
                                                                                     Hello lambda from supplier
                                                                                     BUILD SUCCESSFUL (total time: 0 seconds)
30
              Supplier r4 = () -> { return "Hello lambda from supplier"; }
31
              System.out.println(r4.get());
32
33
```

Primitive Versions of Functional Interfaces [1/2]



Predicate<T>, Consumer<T>, Function<T, R>, and Supplier<T> operate on reference type objects.

Primitive values, such as int, long, float, or double cannot be used with them.

Java 8 provides primitive versions for functional interfaces.

Primitive Versions of Functional Interfaces [2/2]



• Code for use of the primitive versions of the Predicate and Consumer functional interfaces.

```
☐ import java.util.function.*;
13
14
     public class PrimitiveFunctionalInterfacesDemo {
15
          public static void main(String[] args) {
17
              //test IntPredicate
              IntPredicate r1 = arg -> (arg == 10);
18
19
              System.out.println("IntPredicate.test() result: " + r1.test(11));
20
              //test LongConsumer
              LongConsumer r2 = val -> System.out.println("LongConsumer.accept() ←
     result: " + val * val);
                                                            Output - demo lambda (run)
              r2.accept (1000000);
                                                                run:
24
                                                                IntPredicate.test() result: false
                                                                LongConsumer.accept() result: 100000000000
                                                                BUILD SUCCESSFUL (total time: 4 seconds)
```

Binary Versions of Functional Interfaces



- Abstract methods of the Predicate, Consumer, and Function functional interfaces accept one argument.
- Java 8 provides equivalent binary versions of such functional interfaces that can accept two parameters.
- Binary functional version interfaces are prefixed with Bi.

```
☐ import java.util.function.*;
                                                                                 run:
13
                                                                                 BiPredicate.test() result: true
14
     public class BinaryFunctionalInterfacesDemo
                                                                                 BiConsumer.accept() result: Hello Lambda
15
                                                                                 BUILD SUCCESSFUL (total time: 2 seconds)
16
         public static void main(String[] args) {
             // test BiPredicate
             BiPredicate<Integer, Integer> r1 = (arg1, arg2) -> arg1 < arg2;
19
             System.out.println("BiPredicate.test() result: " + r1.test(5, 10));
20
             //test BiConsumer
21
             BiConsumer<String, String> r2 = (arg1, arg2) -> System.out.println("↔
     BiConsumer.accept() result: " + arg1 + arg2);
             r2.accept("Hello ", "Lambda");
24
25
```

Output - demo lambda (run)

UnaryOperator Interface



- Present in the java.util.function package
- Is a specialized version of the Function interface.
- Can be used on a single operand when the types of the operand and result are the same.

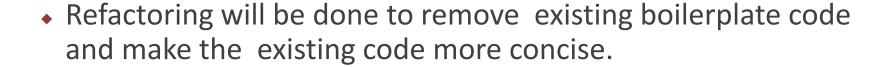
```
import java.util.function.*;
13
14
     public class UnaryOperatorDemo {
15
16
          public static void main(String[] args) {
              UnaryOperator<String> result = (x) -> x.toUpperCase();
18
              System.out.println("Output converted into uppercase:");
19
              System.out.println(result.apply("Hello Lambda"));
20
                                                        Output - demo_lambda (run)
                                                            run:
                                                            Output converted into uppercase:
                                                            HELLO LAMBDA
                                                            BUILD SUCCESSFUL (total time: 0 seconds)
```

Refactoring for Improved Readability [1/3]



Lambda

- Is useful for Java programmers for expressing problems in many situations.
- Its introduction does not break code.
- Existing code can run as it is with new code containing lambdas running along side.





Refactoring for Improved Readability [2/3]



• The code demonstrates how to create the different types of lambdas and use them:

```
12
     public class MultiThreadedAnonymousDemo {
13
          public static void main(String[] args) {
14
              Runnable r1 = new Runnable() {
16
                  @Override
 1 - -
                  public void run() {
18
                      for (int i = 0; i < 5; i++) {
19
                           System.out.println("Hello from anonymous");
20
                           try {
                               Thread. sleep (200);
                           } catch (InterruptedException ex) {
                               ex.printStackTrace();
24
26
27
              };
```





```
29
                Runnable r2 = () \rightarrow {
30
                     for (int i = 0; i < 5; i++) {
31
                          System.out.println("\tHello from lambda");
                          try {
                               Thread. sleep (120);
                           } catch (Exception e) {
                                                                                Output - demo lambda (run)
36
                                                                                    run:
                };
                                                                                   Hello from anonymous
                                                                                           Hello from lambda
                                                                                           Hello from lambda
                Thread t1 = new Thread(r1);
                                                                                   Hello from anonymous
                Thread t2 = new Thread(r2);
40
                                                                                           Hello from lambda
41
                t1.start();
                                                                                           Hello from lambda
                t2.start();
                                                                                    Hello from anonymous
43
                                                                                           Hello from lambda
                                                                                    Hello from anonymous
44
                                                                                    Hello from anonymous
                                                                                    BUILD SUCCESSFUL (total time: 2 seconds)
```

Refactoring Comparison Code [1/2]



- Comparator Interface:
 - Enables comparing the elements of a collection that need to be sorted
 - Is a functional interface that contains the single int compare (T o1, T o2) method.
- When a collection or array needs to be sorted, a Comparator object is passed to the Collections.sort() or Arrays.sort() method.
- The code applies a Comparator using an anonymous inner class

```
class Employee {
    private String firstName;
    private String lastName;

public Employee(String firstName, String lastName) {
        this.firstName = firstName;
        this.lastName = lastName;
}

public String getFirstName() {
        return firstName;
}

public String getLastName() {
        return lastName;
}
```

```
List<Employee> employeeList = new ArrayList<>();
employeeList.add(new Employee("Patrick", "Samuel"));
employeeList.add(new Employee("John", "Doe"));
employeeList.add(new Employee("Andy", "Davidson"));

Collections.sort(employeeList, new Comparator<Employee>() {
    @Override
    public int compare(Employee emp1, Employee emp2) {
        return emp1.getLastName().compareTo(emp2.getLastName());
}

return emp1.getLastName().compareTo(emp2.getLastName());
```

Refactoring Comparison Code [2/2]



• The code snippet applies a Comparator by using a lambda

```
Output - demo_lambda (run)
14
     public class ComparatorLambdaDemo {
                                                                             run:
15
                                                                             Sorted Employee by last name in ascending order
                                                                             Andy Davidson
16
   _
          public static void main(String[] args) {
                                                                             John Doe
17
              List<Employee> employeeList = new ArrayList<>();
                                                                             Patrick Samuel
18
              employeeList.add(new Employee("Patrick", "Samuel"));
                                                                             BUILD SUCCESSFUL (total time: 2 seconds)
19
              employeeList.add(new Employee("John", "Doe"));
20
              employeeList.add(new Employee("Andy", "Davidson"));
21
              Comparator<Employee > sorted = (Employee e1, Employee e2) -> e1.←
22
     getLastName().compareTo(e2.getLastName());
23
24
              System.out.println("Sorted Employee by last name in ascending order");
25
              Collections.sort(employeeList, sorted);
              for (Employee emp : employeeList) {
27
                  System.out.println(emp.getFirstName() + " " + emp.getLastName());
28
29
30
```

Refactoring Concurrency Code [1/3]



• Callable and Future are extensively used in multithread Java applications to implement asynchronous processing.

Callable

- can return a value.
- is a functional interface in the java.util.concurrent package.
- The Callable has a single abstract method, V call().
- When a Callable is passed to a thread pool maintained by **ExecutorService**, the pool selects a thread and execute the Callable.
- The **get()** method of **Future** returns the computation result or block if the computation is not complete.

Refactoring Concurrency Code [2/3]



 The code snippet demonstrates use of an anonymous class to run a piece of code in a different thread with Callable and Future.

```
22
          ExecutorService executor = Executors.newFixedThreadPool(5);
23
          List<Future<String>> list = new ArrayList<>();
          Callable callable = new Callable() {
              @Override
25
              public String call() throws Exception {
27
                  try {
28
                       Thread. sleep (10);
29
                       System.out.println("aaa");
30
                       return Thread.currentThread().getName();
                  } catch (InterruptedException ie) {
31
                       ie.printStackTrace();
33
34
                  return Thread.currentThread().getName();
35
          };
36
37
          for (int i = 0; i < 10; i++) {
38
39
              Future < String > future = executor.submit(callable);
40
              list.add(future);
41
```

Refactoring Concurrency Code [3/3]



 The code snippet demonstrates using lambda to construct a Callable

```
ExecutorService executor = Executors.newFixedThreadPool(5);
23
          List<Future<String>> list = new ArrayList<>();
          Callable callable = () -> {
              try {
26
                  Thread.sleep(10);
                  return Thread.currentThread().getName();
              } catch (InterruptedException ie) {
                  ie.printStackTrace();
30
              return Thread.currentThread().getName();
          };
32
          for (int i = 0; i < 10; i++) {
34
              Future < String > future = executor.submit(callable);
              list.add(future);
36
          for (int i = 0; i<10; i++) {
              try {
                  System.out.println(i+ ": "+list.get(i).get());
39
              } catch (InterruptedException | ExecutionException e) {
40
                  e.printStackTrace();
43
          executor.shutdown();
44
```

```
run:

0: pool-1-thread-1
1: pool-1-thread-2
2: pool-1-thread-3
3: pool-1-thread-4
4: pool-1-thread-5
5: pool-1-thread-1
6: pool-1-thread-4
7: pool-1-thread-5
8: pool-1-thread-3
9: pool-1-thread-3
9: pool-1-thread-2
BUILD SUCCESSFUL (to
```

Debugging Lambdas [1/2]



- To test the lambda used in ComparatorLambdaDemo class :
 - Open the ComparatorLambdaDemo class in NetBeans.
 - o In the code editor, double-click the line number of the statement that uses lambda to set a breakpoint.
 - In the code editor, double-click the line number of the statement containing the for loop to set a breakpoint.

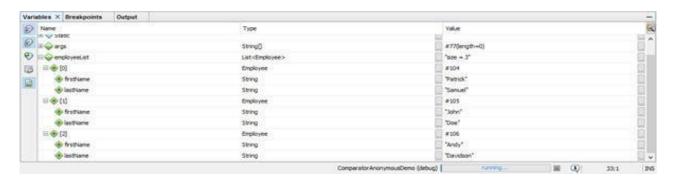


- Select Debug

 Debug Project from the main menu of NetBeans. The program execution stops in the first breakpoint.
- Observe the first name and last name values in the Variables window displayed. At this point, the lambda
 is yet to perform the sorting.

Debugging Lambdas [2/2]



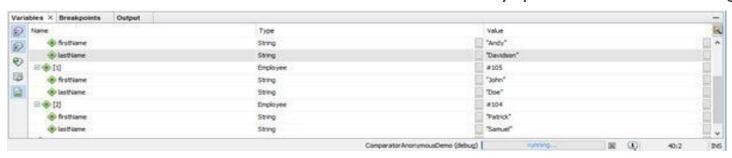


Employee Values before Sorting

Select Debug → Continue from main menu to continue debugging until the debugging thread hits the second breakpoint.

Check the Variables window to ensure that the lambda has correctly performed the sorting based on the

last name.



Employee Values after Sorting

Select Debug → Finish Debugger Session to stop debugging.

Summary



- A lambda expression is an unnamed block of code that facilitates functional programming.
- java.util.function package introduced in Java 8 contains a large number of functional interfaces.
- Java 8 provides primitive versions for functional interfaces to operate on primitive values.
- Java 8 also provides equivalent binary versions of some functional interfaces that can accept two parameters.
- UnaryOperator interface is used on a single operand when the types of the operand and result are the same.
- Java programmers can use lambdas to express problems in a shorter and more readable way.
- Lambda expressions can be debugged in NetBeans like any piece of Java code by setting breakpoints.