Lambdas & Streams

Nashwan Gubeljli [Pexels]

Inner Class Access

- An inner class (ex: anon observer class) can access..
  all variables & methods visible in the enclosing scope

- Including:
  - Local variables & parameters;
    must be final (or effectively final)
  - Fields & methods of containing object.
  - Fields & methods of inner class
- How?
  - Inner class automatically.. creates a reference to containing object and needed local variables.

Inner Class and Final Local Variables

final variable: var does not change

- Why can inner class access only final local variables?
  - inner class runs much later than containing function
  - So parameters and local variables no longer exist. But, Java makes copy of needed local variables/parameters.
    - Called.. capturing variables
  - If variable not final, Java does not know which value to capture.
- Effectively Final
  - Detects if a variable..

is not changed after initialized

  - Effectively final OK for capturing variable.

if initialized x
then change x
—> error later

Observer is interface

```
void foo(int x) {
  // Don't change x!
  // x = 42;
  model.addObserver(new Observer() {
    @Override
    public void event() {
      System.out.println("VAL: " + x);
    }
  });
}
```

Lambda Expression

- Awkward to create anon classes for small interfaces
  - Lambda expressions can be used instead when..
    interface has only one method

Use an anon-inner class:

```
void foo(int x) {
        myModel.addObserver(new DaObserver() {
                @Override
                public void dataChanged(int newVal) {
                        System.out.println(newVal);
                }
        });
}
```

Use a lambda expression:

```
void foo() {
        myModel.addObserver(
          (newVal) -> System.out.println(newVal)
        );
}
```

Syntax:
arg -> statement

Lambda Notes

- Compactness
  - Functional interface: an interface with one method
  - Prefer lambda expressions over anonymous classes for functional interfaces: they are way shorter!
- Clarity
  - Lambdas don’t state the type of their argument: So, name parameters carefully
  - Don’t express long operations as lambdas.

Method References

- Situation
  You are using a lambda expression to just call a function, passing along all the parameters

```
obj.register( x -> procssEvent(x) );
```

- Solution
  Use a method reference:
  reference the method name without arguments or lambda
  ..

```
obj.register( this::procssEvent );
```

Method Reference

```
interface Observer {
    void event(String description);
}
class Model {
    public void addObserver(Observer obs) {
        // ...
    }
}
```

```
class Client {
    public void regObserver() {
        Model model = new Model();

        // Option 1: Anonymous Class
        model.addObserver(new Observer() {
            @Override
            public void event(String description) {
                handleEvent(description);
            }
        });

        // Option 2: Lambda
        model.addObserver(msg -> handleEvent(msg));

        // Option 3: Method Reference
        model.addObserver(this::handleEvent);
    }

    private void handleEvent(String description) {
        System.out.println(description);
    }
}
```

Streams

Streams

- Stream
  - a sequence of objects supporting a pipeline of operations
  - *Think of it like a parade.*
- Stream Pipeline
  - Combine stream operations to process elements in a stream
  - Can be done in parallel
  - *Think of it like doing something to each vehicle in a parade.*
- Example

```
List<Double> heights_m =
       Arrays.asList(10.0, 30.0, 20.0, 60.0, 50.0);

heights_m.stream()
    .map(x -> x * x)
    .forEach(x -> System.out.println(x));
```

```
100.0
900.0
400.0
3600.0
2500.0
```

Pipelines

- About Streams
  - Streams process elements of a collection (or generating func.)
  - Streams don't change the data structure,
    they operate on the elements
- Stream Pipeline built out of:
  - source stream: Provides the stream
  - intermediate operations: Operates on stream; returns stream
  - terminal operation: Collects result as desired for return

```
List<Double> heights_m =
       Arrays.asList(10.0, 30.0, 20.0, 60.0, 50.0);

heights_m.stream()
   .map(x -> x * x)
   .forEach(x -> System.out.println(x));
```

Examples

```
class Student
    implements Comparable<Student>
{
    private String name;
    private double gpa;
    private int creditHours;
    // ... constructor, getters,
    //     compareTo(),
}



List<Student> students =
  Arrays.asList(
   new Student("Bill", 1.68, 52),
   new Student("Alice", 3.5, 40),
   new Student("Doris", 4.01, 102),
   new Student("Charlie", 3.8, 12)
  );
```

```
// Terminal Operation: forEach
// ( Assume sout() is System.out.println(...) )
students.stream()
        .forEach(std -> sout(std.getName()));

// Intermediate Operation: filter
students.stream()
        .filter(std -> std.getGpa() >= 3.5)
        .forEach(std -> sout(std.getName()));

// Terminal Operation: count
long numFailing = students.stream()
        .filter(std -> std.getGpa() < 1.0)
        .count();

// Terminal Operation: collect
List<Student> honourRoll = students.stream()
        .filter(std -> std.getGpa() >= 3.5)
        .collect(Collectors.toList());
List<Student> studentsWithL = students.stream()
        .filter(std -> std.getName().contains("l"))
        .collect(Collectors.toList());

// Intermediate Operation: sorted()
List<Student> sorted = students.stream()
        .sorted()
        .collect(Collectors.toList());
```

Pipeline Operations

- Intermediate Operations
  - filter: Keep only wanted elements
    int n = students.stream().**filter(**std -> std.getGpa() >= 3.5**)**.count();
  - sorted: Reorder stream elements
    List<Student> sorted =
        students.stream().**sorted()**.collect(Collectors.toList());
  - map: Apply a transformation to each element (later)
- Terminal Operations
  - count(): # elements
    int num = students.stream().**count()**;
  - collect(): To a type
    List<Student> sts = stds.stream().filter(...).**collect(**Collectors.toList()**)**;
  - forEach(): Do on each
    stds.stream().filter(...).**forEach(**s -> System.out.println(s.getName()**)**);

Examples: Map & Reduce

```
// Map (intermediate) – Transform value or type
// Map to change the value
List<Double> heights_m = Arrays.asList(10.0, 30.0, 20.0, 60.0, 50.0);
final double INCHES_PER_M = 39.3701;
List<Double> heights_inch = heights_m.stream()
        .map( m -> m * INCHES_PER_M)
        .collect(Collectors.toList());

// Map to change the type
List<String> honourRoleNames = students.stream()
        .filter(std -> std.getGpa() >= 3.5)
        .map(std -> std.getName())
        .collect(Collectors.toList());

// Reduce (terminal) – Combine elements
// Takes stream of type Z and returns one element of type Z
String message = "Student names: " + students.stream()
        .map(std -> std.getName())
        .reduce("", (ans, name) -> ans + "," + name);
// This is the same as:
String messageJoin = "Student names: " + students.stream()
        .map(std -> std.getName())
        .collect(Collectors.joining(", "));
```

int, long, double Streams

- Streams operate on a sequence of objects
  - IntStream/LongStream/DoubleStream operate on a sequence of primitives

```
// mapToInt() and sum()
int allHours = students.stream()
                .mapToInt( std -> std.getCreditHours() )
                .sum();

// Max/Min/Avg may fail if stream is empty, so they return an Optional
// Must call "orElse()" on the optional to get a default value
double maxGpa = students.stream()
                .mapToDouble( std -> std.getGpa() )
                .max().orElse(0);

// IntStream.range() to generate a stream
int sumEvens = IntStream.range(0, 100)
        .filter(x -> x % 2 == 0)
        .sum();
```

Stream Tips

- Stream API is fluent
  - Each intermediate stream operation returns a stream, so can chain operations together in one statement.
- Use streams when they simplify your code
  - Overuse makes code very hard to read
  - Use helper methods to simplify your code and add semantic value to otherwise complex statements
- Naming functions
  - Plural name for functions which return a stream: students(), courses(),...

Summary

- Inner classes can access effectively final local variables.
- Lambda expressions replace most anonymous classes.
- Method references replace some lambdas
- Streams and stream pipelines replace some iteration:
  - intermediate operations transform/filter elements
  - terminal operations collect elements at end
- Fluent API: Functions return same type of object as their class (allows chaining)