Chapter 9

Streams

Business Training

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Collection Streams and Filters

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What Is a Stream?

- **A stream is a sequence of elements (you can think of these elements as data) that can be processed with operations.**
  - That's plenty vague as a definition, so to get a better handle on what a stream is, let's make one:

```
Integer[] myNums = { 1, 2, 3 };
Stream<Integer> myStream = Arrays.stream(myNums);
```

  - The resulting stream, myStream, is a stream of Integers. What does the stream look like?
    - System.out.println(myStream);
  - This results in the output: `java.util.stream.ReferencePipeline$Head@14ae5a5`
    - Initially, you might think that a stream is a bit like a data structure, like a List or an array.
    - But streams are not a data structure to organize data like a List is or an array is; rather, they are a way to process data that you can think of as flowing through the stream, much like water flows through a stream in the real world.

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Why Streams ?

- **The main reason to use streams is when you start doing multiple intermediate operations.**
  - So far, we've been performing only one intermediate operation: a filter, using a variety of different Predicates to filter the data we get from the stream before we count it.
  - However, when we use multiple intermediate operations, we start seeing the benefits of streams.
- **You're probably saying to yourself, what's the big deal? We could do the same thing using iteration, right?**
  - The big deal is that streams use something called a "pipeline," which can, in some circumstances, **dramatically improve the efficiency of data processing.**

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How to create a Stream ?

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How to Create a Stream ?

- **Create a Stream from a Collection**

```
List<Double> tempsInPhoenix = Arrays.asList(123.6, 118.0, 113.0, 112.5,
     115.8, 117.0, 110.2, 110.1, 106.0, 106.4);
System.out.println("Number of days over 110 in 10 day period: " +
tempsInPhoenix
    .stream()                  // stream the List of Doubles
    .filter(t -> t > 110.0)    // filter the stream
    .count());                 // count the Doubles that pass the filter test
```

- **Build a Stream with Stream.of()**

```
Integer[] myNums = { 1, 2, 3 };
Stream<Integer> myStream = Stream.of(myNums);
```

- **Create a Stream from an Array**

```
String[] dogs = { "Boi", "Zooey", "Charis" };        // make an array
Stream<String> dogStream = Arrays.stream(dogs);      // stream it
System.out.println("Number of dogs in array: " + dogStream.count()); // count it
```

- **Create a Stream from a File**

```
Stream<String> stream = Files.lines(Paths.get(filename)));
```

- **Primitive Value Streams**

```
DoubleStream s3 = DoubleStream.of(406.13, 406.42, 407.18, 409.01);
```


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Summary of Methods to Create Streams

Interface/Class	Creates a...	With method...
`Collection`	`Stream<E>`	`stream()`
`Arrays`	`Stream<T>`	`stream(T[] array)` `stream(T[] array, int startInclusive, int endExclusive)`
`Arrays`	`IntStream`, `DoubleStream`, `LongStream`	`stream(int[] array)`, `stream(double[] array)`, `stream(long[] array)` (and versions with start/end like `Stream`)
`Files`	`Stream<String>`	`lines(Path path)`, `lines(Path path, Charset cs)`
`Stream`	`Stream<T>`	`of(T... values)`, `of(T t)`
`DoubleStream`	`DoubleStream`	`of(double... values)`, `of(double t)`
`IntStream`	`IntStream`	`of(int... values)`, `of(int t)`
`LongStream`	`LongStream`	`of(long... values)`, `of(long t)`

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The Stream Pipeline

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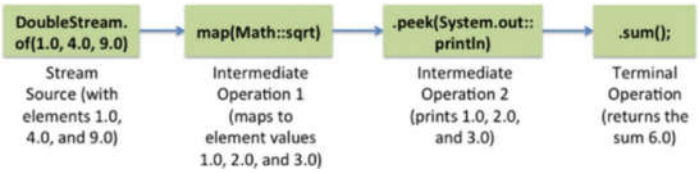
An example of Stream pipeline

- **A stream pipeline with source, intermediate operations and terminal operation**
  - Example : You can use map() and peek() methods in primitive versions of Stream<T>; then following code snippet uses a DoubleStream:

```
DoubleStream.of(1.0, 4.0, 9.0)
        .map(Math::sqrt)
        .peek(System.out::println)
        .sum();
```

  - This code prints 1.0, 2.0, and 3.0 in separate lines on the console. Figure 6-1 visually shows the source, intermediate operations and the terminal operations in this stream pipeline.



  - the peek() method is meant primarily for debugging purposes. It helps us understand how the elements are transformed in the pipeline. Do not use it in production code.

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Search Data from a Stream

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Search Data from a Stream

- **Methods ending with the word "Match" and methods starting with the word "find" in the Stream interface are useful for searching data from the stream**
- **Important Match and Find Methods in the Stream Interface**

Method Name	Short Description
`boolean anyMatch(Predicate<? super T> check)`	Returns true if there is any elements in the stream that matches the given predicate. Returns false if the stream is empty or if there are no matching elements.
`boolean allMatch(Predicate<? super T> check)`	Returns true only if *all* elements in the stream matches the given predicate. Returns true if the stream is empty without evaluating the predicate!
`boolean noneMatch(Predicate<? super T> check)`	Returns true only if *none* of the elements in the stream matches the given predicate. Returns true if the stream is empty without evaluating the predicate!
`Optional<T> findFirst()`	Returns the first element from the stream; if there is no element present in the stream, it returns an empty `Optional<T>` object.
`Optional<T> findAny()`	Returns one of the elements from the stream; if there is no element present in the stream, it returns an empty `Optional<T>` object.

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Search Data from a Stream

- **Here is a simple program that illustrates how to use anyMatch(), allMatch(), and noneMatch() methods**

```
// Average temperatures in Concordia, Antarctica in a week in October 2015
boolean anyMatch
        = IntStream.of(-56, -57, -55, -52, -48, -51, -49).anyMatch(temp -> temp > 0);
System.out.println("anyMatch(temp -> temp > 0): " + anyMatch);

boolean allMatch
        = IntStream.of(-56, -57, -55, -52, -48, -51, -49).allMatch(temp -> temp > 0);
System.out.println("allMatch(temp -> temp > 0): " + allMatch);

boolean noneMatch
        = IntStream.of(-56, -57, -55, -52, -48, -51, -49).noneMatch(temp -> temp > 0);
System.out.println("noneMatch(temp -> temp > 0): " + noneMatch);
```

  - This program prints:

    anyMatch(temp -> temp > 0): false

    allMatch(temp -> temp > 0): false

    noneMatch(temp -> temp > 0): true

    - Unlike the anymatch() method that returns false when the stream is empty, the allmatch() and nonematch() methods return true if the stream is empty!

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The Optional class

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Stream Methods That Return Optionals

Interface	Method	Returns...
Stream	findAny()	Optional<T>
Stream	findFirst()	Optional<T>
Stream	max(Comparator<? super T> comparator)	Optional<T>
Stream	min(Comparator<? super T> comparator)	Optional<T>
Stream	reduce(BinaryOperator<T> accumulator)	Optional<T>
DoubleStream	average()	OptionalDouble
DoubleStream	findAny(), findFirst()	OptionalDouble
DoubleStream	max(), min()	OptionalDouble
DoubleStream	reduce(DoubleBinaryOperator op)	OptionalDouble
IntStream, LongStream	Similar methods to DoubleStream	OptionalInt, OptionalLong

The Optional class

- **The class java.util.Optional is a holder for value that can be null. There are numerous methods in classes in java.util.stream package that return Optional values. Let us see an example now.**

```
public static void selectHighestTemperature(Stream<Double> temperatures) {
    System.out.println(temperatures.max(Double::compareTo));
}
```

  - Here is a call to this method:

```
selectHighestTemperature(Stream.of(24.5, 23.6, 27.9, 21.1, 23.5, 25.5, 28.3));
```

    - This code prints: Optional[28.3]
  - The max() method in Stream takes a Comparator as an argument and returns an Optional<T>:

```
Optional<T> max(Comparator<? super T> comparator);
```

  - Why Optional<T> instead of return type T?
    - It is because max() method may fail to find the maximum value – think about an empty stream, for example: `selectHighestTemperature(Stream.of());`
    - Now, this code prints: Optional.empty
  - To get the value from Optional, you can use isPresent() and get() methods, as in:

```
public static void selectHighestTemperature(Stream<Double> temperatures) {
    Optional<Double> max = temperatures.max(Double::compareTo);
    if(max.isPresent()) {
        System.out.println(max.get());
    }
}
```

Creating Optional Objects

- **There are many ways to create Optional objects. One way to create Optional objects is to use factory methods in Optional class, as in:**

```
Optional<String> empty = Optional.empty();
```

  - You can also use of() in Optional class:

```
Optional<String> nonEmptyOptional = Optional.of("abracadabra");
```

  - However, you cannot pass null to Optional.of() method, as in:

```
Optional<String> nullStr = Optional.of(null);
System.out.println(nullStr);
// crashes with a NullPointerException
```

- **This will result in throwing a NullPointerException. If you want to create an Optional object that has null value, then you can instead use ofNullable() method:**

```
Optional<String> nullableStr = Optional.ofNullable(null);
System.out.println(nullableStr);
// prints: Optional.empty
```


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Stream Data Methods and Calculation Methods

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Important Data and Calculation Methods in IntStream Interface

- **The Stream<T> interface has data and calculation methods count(), min() and max().**
  - Example:

```
String[] string = "you never know what you have until you clean your room".split(" ");
System.out.println(Arrays.stream(string).min(String::compareTo).get());
```

  - This program prints: clean

- **Important Data and Calculation Methods in IntStream Interface**

Method	Short Description
`int sum()`	Returns the sum of elements in the stream; 0 in case the stream is empty.
`long count()`	Returns the number of elements in the stream; 0 if the stream is empty.
`OptionalDouble average()`	Returns the average value of the elements in the stream; an empty `OptionalDouble` value in case the stream is empty.
`OptionalInt min()`	Returns the minimum integer value in the stream; an empty `OptionalInt` value in case the stream is empty.
`OptionalInt max()`	Returns the maximum integer value in the stream; an empty `OptionalInt` value in case the stream is empty.
`IntSummaryStatistics summaryStatistics()`	Returns an `IntSummaryStatistics` object that has `sum`, `count`, `average`, `min`, and `max` values.

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Sort a Collection Using Stream API

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Sort a Collection Using Stream API

- **We discussed how to sort a collection using Comparator and Comparable interfaces.**
  - Streams simplify the task of sorting a collection.
- **Here is a program that sorts strings with lexicographical comparison**

```
List words =
        Arrays.asList("follow your heart but take your brain with you".split(" "));
words.stream().distinct().sorted().forEach(System.out::println);
```

  - This program prints: **brain but follow heart take with you your**
  - Here is the modified version of the earlier program that sorts the elements based on the length of the strings.

```
List words =
        Arrays.asList("follow your heart but take your brain with you".split(" "));
Comparator<String> lengthCompare = (str1, str2) -> str1.length() - str2.length();
words.stream().distinct().sorted(lengthCompare).forEach(System.out::println);
```

  - This program prints: **but you take with your brain heart follow**

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Save Results to a Collection

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Save Results to a Collection

- **The Collectors class has methods that support the task of collecting elements to a collection.**
  - You can use methods such as **toList(), toSet(), toMap(),** and toCollection() to create a collection from a stream.

```
String frenchCounting = "un:deux:trois:quatre";
List gmailList = Pattern.compile(":")
        .splitAsStream(frenchCounting)
        .collect(Collectors.toList());
gmailList.forEach(System.out::println);
```

    - The collect() method in Stream takes a Collector as an argument:

    <R, A> R collect(Collector<? super T, A, R> collector);

  - Just like Lists and Sets, you can also create Maps from a stream.

```
Map<String, Integer> nameLength = Stream.of("Arnold", "Alois", "Schwarzenegger")
        .collect(Collectors.toMap(name -> name, name -> name.length()));
nameLength.forEach((name, len) -> System.out.printf("%s - %d \n", name, len));
```

    - This program prints: Alois - 5
      Schwarzenegger - 14
      Arnold - 6

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Using flatMap Method in Stream

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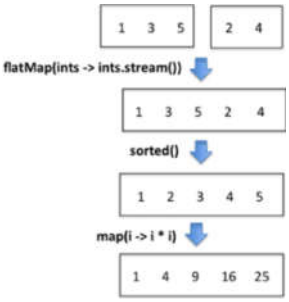
Using FlatMap

- **Let's suppose we have a List of List<Integer>**

```
List<List<Integer>> intsOfInts = Arrays.asList(
                                 Arrays.asList(1, 3, 5),
                                 Arrays.asList(2, 4));
intsOfInts.stream()
        .flatMap(ints -> ints.stream())
            .sorted()
            .map(i -> i * i)
            .forEach(System.out::println);
```



  - This prints the squares of the values 1 to 5.
- To convert those streams into Integer elements, we call the **flatMap()** method. After the call to flatMap(), we have a stream of Integers. We can now perform operations such as **sorted(),** and **map()** to process or transform those elements.

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Map-Filter-Reduce with average() and Optionals

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Using reduce()

- **The methods count(), average(), min(), max(), and sum() are all reduction methods already defined on streams.**
  - You can also define your own reductions using the reduce() method.
  - If we look at the type signature of DoubleStream.reduce(), we see:

```
OptionalDouble reduce(DoubleBinaryOperator op)
```

  - To write our own method to sum all the values in the stream using reduce(), we pass a **DoubleBinaryOperator** to reduce(), which adds the two arguments together and returns the sum:

```
OptionalDouble sum =
    readings.stream()
        .mapToDouble(r -> r.value)
        .reduce((v1, v2) -> v1 + v2);
if (sum.isPresent()) {
    System.out.println("Sum of all readings: " + sum.getAsDouble());
}
```

    - And we see the output: `Sum of all readings: 2843.8600000000006`
  - There's another reduce() method in DoubleStream that takes an ***identity*** along with an accumulator function and returns a double:

```
double reduce(double identity, DoubleBinaryOperator op)
```

    - The identity argument serves two roles: it provides an initial value and a value to return if the stream is empty.

```
double sum = readings.stream()
   .mapToDouble(r -> r.value)
   .reduce(0.0, (v1, v2) -> v1 + v2);              // provide an identity
value
System.out.println("Sum of all readings: " + sum); // print 0.0 if stream
                                                   // is empty
```