Understand Java Parallel Streams Internals: Combining Results (Part 2)

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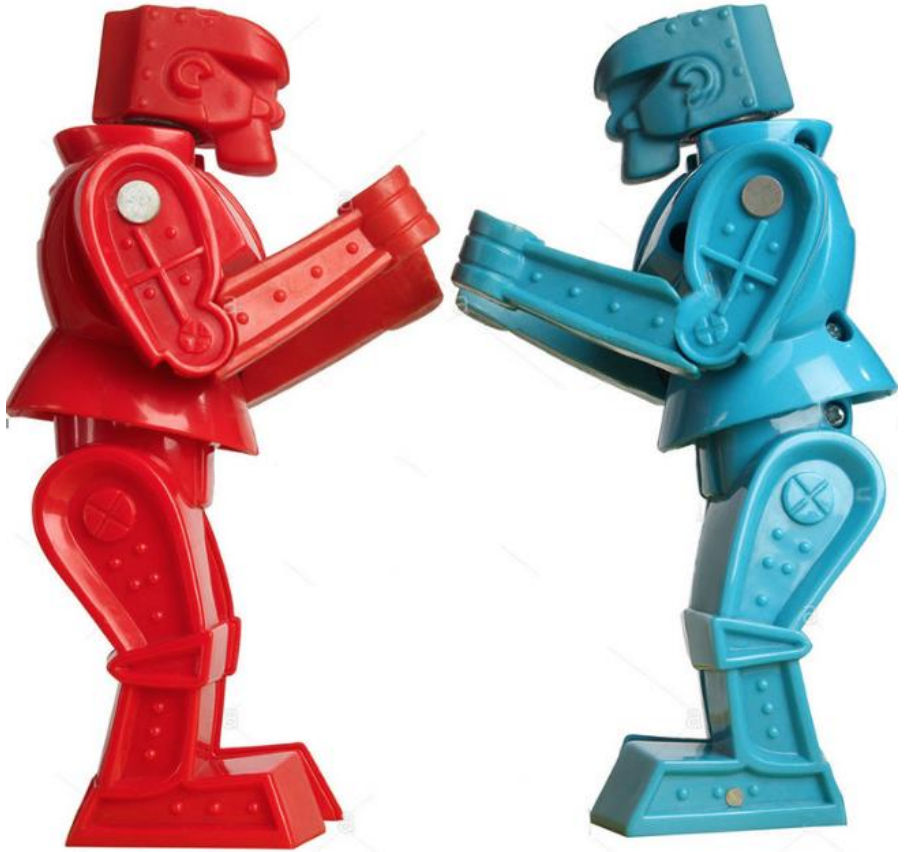
Learning Objectives in this Part of the Lesson

- Understand parallel stream internals, e.g.
  - Know what can change & what can't
  - Partition a data source into "chunks"
  - Process chunks in parallel via the common fork-join pool
  - Configure the Java parallel stream common fork-join pool
  - Perform a reduction to combine partial results into a single result
    - Be aware of common traps & pitfalls with parallel streams

Differences for collect() & reduce() in a Parallel Stream

Differences for collect() & reduce() in a Parallel Stream

- It's important to understand the semantic differences between collect() & reduce()



Differences for collect() & reduce() in a Parallel Stream

- It's important to understand the semantic differences between collect() & reduce(), e.g.
  - Always test w/a parallel stream to detect mistakes wrt mutable vs. immutable reductions

```
void buggyStreamReduce3
        (boolean parallel) {
  ...
  Stream<String> wordStream =
    allWords.stream();

  if (parallel)
    wordStream.parallel();

  String words = wordStream
    .reduce(new StringBuilder(),
            StringBuilder::append,
            StringBuilder::append)
    .toString();
```

See github.com/douglascraigschmidt/LiveLessons/tree/master/Java8/ex17

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Convert a list of words into a stream of words

```
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        (boolean parallel) {
...
Stream<String> wordStream =
  allWords.stream();

if (parallel)
  wordStream.parallel();

String words = wordStream
  .reduce(new StringBuilder(),
          StringBuilder::append,
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  .toString();
```

Naturally, this call doesn't really do any work since streams are "lazy"

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A stream can be dynamically switched to "parallel" mode!

```
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    .toString();
```

See docs.oracle.com/javase/8/docs/api/java/util/stream/BaseStream.html#parallel

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The "last" call to .parallel() or .sequential() in a stream "wins"

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```

See mail.openjdk.java.net/pipermail/lambda-libs-spec-experts/2013-March/001504.html

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This code works when parallel is false since the StringBuilder is only called in a single thread

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See docs.oracle.com/javase/8/docs/api/java/lang/StringBuilder.html

Differences for collect() & reduce() in a Parallel Stream

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This code fails when parallel is true since reduce() expects to do an "immutable" reduction

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There's a race condition here since StringBuilder is not thread-safe..

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    wordStream.parallel();

  String words = wordStream
    .reduce(new StringBuilder(),
            StringBuilder::append,
            StringBuilder::append)
    .toString();
```

See www.baeldung.com/java-string-builder-string-buffer

Differences for collect() & reduce() in a Parallel Stream

- It's important to understand the semantic differences between collect() & reduce(), e.g.
  - Always test w/a parallel stream to detect mistakes wrt mutable vs. immutable reductions
    - One solution use reduce() with string concatenation

```
void streamReduceConcat
        (boolean parallel) {
  ...
  Stream<String> wordStream =
    allWords.stream();

  if (parallel)
    wordStream.parallel();

  String words = wordStream
    .reduce(new String(),
            (x, y) -> x + y);
```

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Differences for collect() & reduce() in a Parallel Stream

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        (boolean parallel) {
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  Stream<String> wordStream =
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    .reduce(new String(),
            (x, y) -> x + y);
```

This simple fix is inefficient due to string concatenation overhead

See javarevisited.blogspot.com/2015/01/3-examples-to-concatenate-string-in-java.html

Differences for collect() & reduce() in a Parallel Stream

- It's important to understand the semantic differences between collect() & reduce(), e.g.
  - Always test w/a parallel stream to detect mistakes wrt mutable vs. immutable reductions
    - One solution use reduce() with string concatenation
    - Another solution uses collect() with the joining collector

```
void streamCollectJoining
        (boolean parallel) {
  ...
  Stream<String> wordStream =
    allWords.stream();

  if (parallel)
    wordStream.parallel();

  String words = wordStream
    .collect(joining());
```

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Differences for collect() & reduce() in a Parallel Stream

- It's important to understand the semantic differences between collect() & reduce(), e.g.
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    - One solution use reduce() with string concatenation
    - Another solution uses collect() with the joining collector

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        (boolean parallel) {
  ...
  Stream<String> wordStream =
    allWords.stream();

  if (parallel)
    wordStream.parallel();

  String words = wordStream
    .collect(joining());
```

This is a much better solution!!

See www.mkyong.com/java8/java-8-stringjoiner-example

Differences for collect() & reduce() in a Parallel Stream

- Also beware of issues related to associativity & identity with reduce()

```
void testDifferenceReduce(...) {
  long difference = LongStream
    .rangeClosed(1, 100)
    .parallel()
    .reduce(0L,
            (x, y) -> x - y);
}

void testSum(long identity, ...) {
  long sum = LongStream
    .rangeClosed(1, 100)
    .reduce(identity,
     // Could use (x, y) -> x + y
           Math::addExact);
```

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    .reduce(identity,
     // Could use (x, y) -> x + y
           Math::addExact);
```

This code fails for a parallel stream since subtraction is not associative

See developer.ibm.com/articles/j-java-streams-2-brian-goetz

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void testSum(long identity, ...) {
  long sum = LongStream
    .rangeClosed(1, 100)
    .reduce(identity,
     // Could use (x, y) -> x + y
            Math::addExact);
```

This code fails if identity is not 0L

The "identity" of an OP is defined as "identity OP value == value" (& inverse)

Differences for collect() & reduce() in a Parallel Stream

- Also beware of issues related to associativity & identity with reduce()

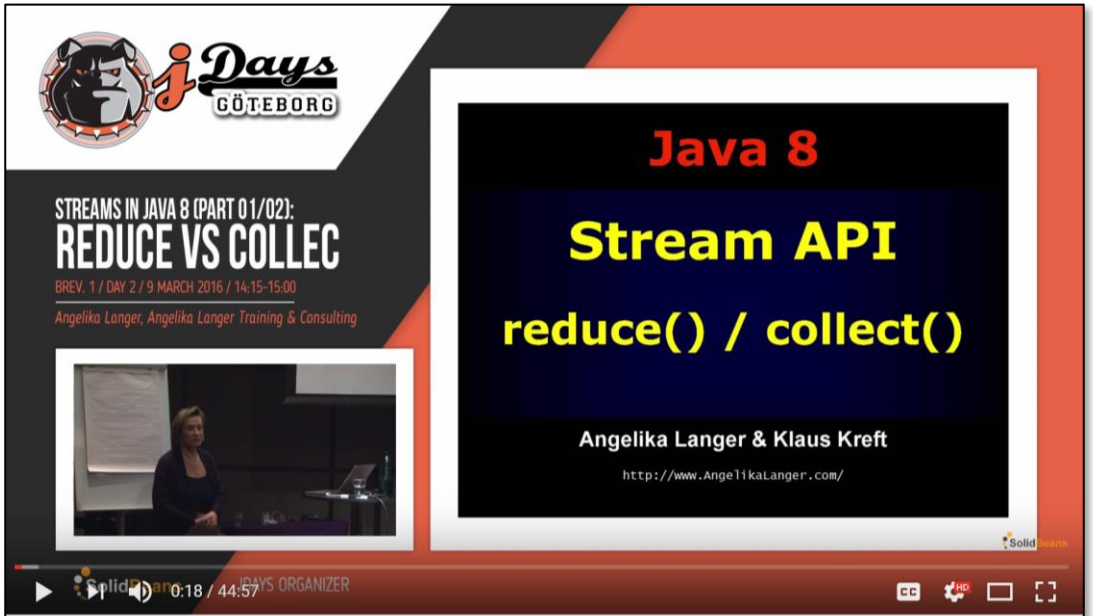
```
void testDifferenceReduce(...) {
  long difference = LongStream
    .rangeClosed(1, 100)
    .parallel()
    .reduce(0L,
            (x, y) -> x - y);
}

void testProd(long identity, ...) {
  long sum = LongStream
    .rangeClosed(1, 100)
    .reduce(identity,
            (x, y) -> x * y);
```

This code fails if identity is not 1L

Differences for collect() & reduce() in a Parallel Stream

- More good discussions about reduce() vs. collect() appear online



See www.youtube.com/watch?v=oWlWEKNM5Aw

End of Understand Java Parallel Streams Internals: Combining Results (Part 2)