Learn When to Not to Use Java Parallel Streams

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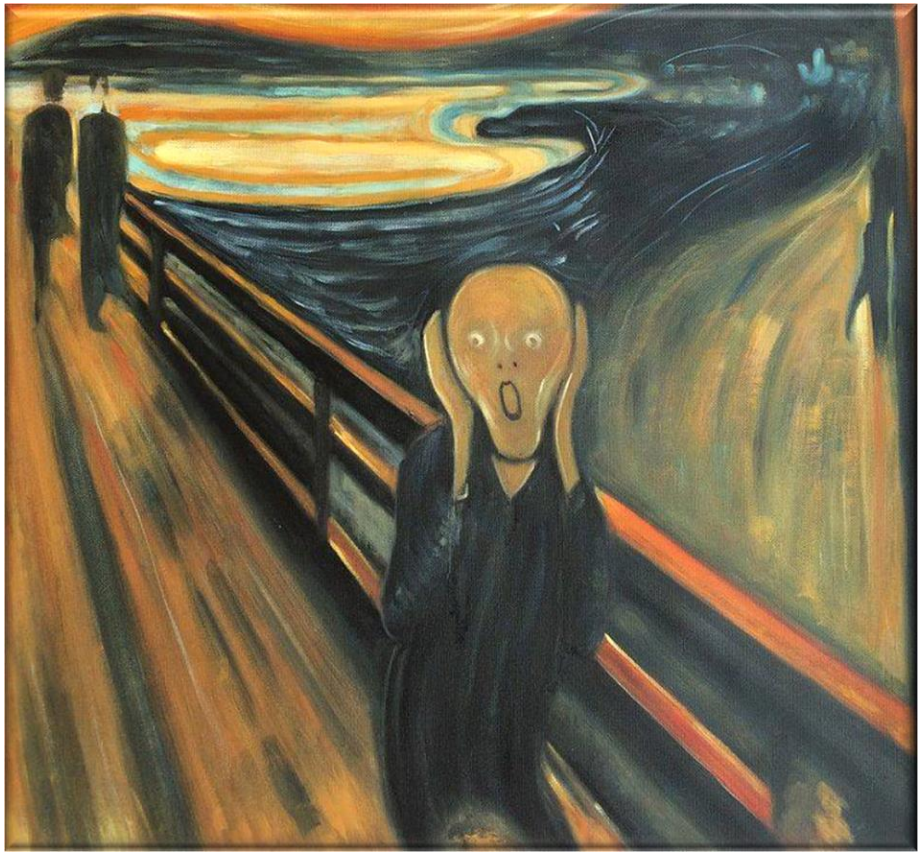
Learning Objectives in this Part of the Lesson

- Learn when to use parallel streams
  - & when *not* to use parallel streams

When Not to Use Java Parallel Streams

When Not to Use Java Parallel Streams

- Parallel streams aren't suitable for certain types of programs



See developer.ibm.com/articles/j-java-streams-5-brian-goetz

When Not to Use Java Parallel Streams

- Parallel streams aren't suitable for certain types of programs, e.g.
  - The source is expensive to split or splits unevenly

```
List<CharSequence> arrayAllWords =
  TestDataFactory.getInput
    (sSHAKESPEARE_WORKS, "\\s+");

List<CharSequence> listAllWords =
  new LinkedList<>(arrayAllWords);


arrayAllWords.parallelStream()
             ...;

listAllWords.parallelStream()
             ...;
```

See github.com/douglascraigschmidt/LiveLessons/tree/master/Java8/ex14

When Not to Use Java Parallel Streams

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Make an ArrayList that contains all words in the works of Shakespeare

```
List<CharSequence> arrayAllWords =
  TestDataFactory.getInput
    (sSHAKESPEARE_WORKS, "\\s+");

List<CharSequence> listAllWords =
  new LinkedList<>(arrayAllWords);


arrayAllWords.parallelStream()
             ...;

listAllWords.parallelStream()
            ...;
```

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  TestDataFactory.getInput
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List<CharSequence> listAllWords =
  new LinkedList<>(arrayAllWords);
```

Make a LinkedList that contains all words in the works of Shakespeare

```
arrayAllWords.parallelStream()
             ...;

listAllWords.parallelStream()
            ...;
```

LinkedList doesn't split evenly or efficiently compared with ArrayList

When Not to Use Java Parallel Streams

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```
Starting spliterator tests for 100000
words....printing results
    599 msecs: ArrayList parallel
    701 msecs: LinkedList parallel

Starting spliterator tests for 883311
words....printing results
   5718 msecs: ArrayList parallel
  31226 msecs: LinkedList parallel
```

```
List<CharSequence> arrayAllWords =
  TestDataFactory.getInput
    (sSHAKESPEARE_WORKS, "\\s+");

List<CharSequence> listAllWords =
  new LinkedList<>(arrayAllWords);


arrayAllWords.parallelStream()
             ...;

listAllWords.parallelStream()
             ...;
```

The ArrayList parallel stream is much faster than the LinkedList parallel stream.

See earlier lesson on "*Java Parallel Stream Internals: Demo'ing Spliterator Performance*"

When Not to Use Java Parallel Streams

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The ArrayList spliterator runs in O(1) constant time

```
class ArrayListSpliterator {
  ...
  ArrayListSpliterator<E>
    trySplit() {
    int hi = getFence(), lo =
      index, mid = (lo + hi) >>> 1;
    return lo >= mid
          ? null
          : new
          ArrayListSpliterator<E>
           (list, lo, index = mid,
            expectedModCount);
  }
  ...
```

See openjdk/8u40-b25/java/util/ArrayList.java

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           ArrayListSpliterator<E>
            (list, lo, index = mid,
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  }
  ...
```

Compute the mid-point efficiently

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  ...
  ArrayListSpliterator<E>
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      index, mid = (lo + hi) >>> 1;
    return lo >= mid
         ? null
         : new
         ArrayListSpliterator<E>
          (list, lo, index = mid,
           expectedModCount);
  }
  ...
```

Split the array list evenly without copying the data

When Not to Use Java Parallel Streams

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```
class LLSpliterator {
  ...
  public Spliterator<E> trySplit(){
    ...
    int n = batch + BATCH_UNIT;
    ...
    Object[] a = new Object[n];
    int j = 0;
    do { a[j++] = p.item; }
    while ((p = p.next) != null
           && j < n);
    ...
    return Spliterators
      .spliterator(a, 0, j,
                   Spliterator.ORDERED);
```

The LinkedList spliterator runs in O(n) linear time

See openjdk/8-b132/java/util/LinkedList.java

When Not to Use Java Parallel Streams

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Create a fixed-size chunk

```
class LLSpliterator {
  ...
  public Spliterator<E> trySplit(){
    ...
    int n = batch + BATCH_UNIT;
    ...
    Object[] a = new Object[n];
    int j = 0;
    do { a[j++] = p.item; }
    while ((p = p.next) != null
           && j < n);
    ...
    return Spliterators
      .spliterator(a, 0, j,
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```

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class LLSpliterator {
  ...
  public Spliterator<E> trySplit(){
    ...
    int n = batch + BATCH_UNIT;
    ...
    Object[] a = new Object[n];
    int j = 0;
    do { a[j++] = p.item; }
    while ((p = p.next) != null
           && j < n);
    ...
    return Spliterators
      .spliterator(a, 0, j,
                   Spliterator.ORDERED);
```

Copy data into the chunk

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```
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  ...
  public Spliterator<E> trySplit(){
    ...
    int n = batch + BATCH_UNIT;
    ...
    Object[] a = new Object[n];
    int j = 0;
    do { a[j++] = p.item; }
    while ((p = p.next) != null
           && j < n);
    ...
    return Spliterators
      .spliterator(a, 0, j,
                   Spliterator.ORDERED);
```

Create a new spliterator that covers the chunk

When Not to Use Java Parallel Streams

- Parallel streams aren't suitable for certain types of programs, e.g.
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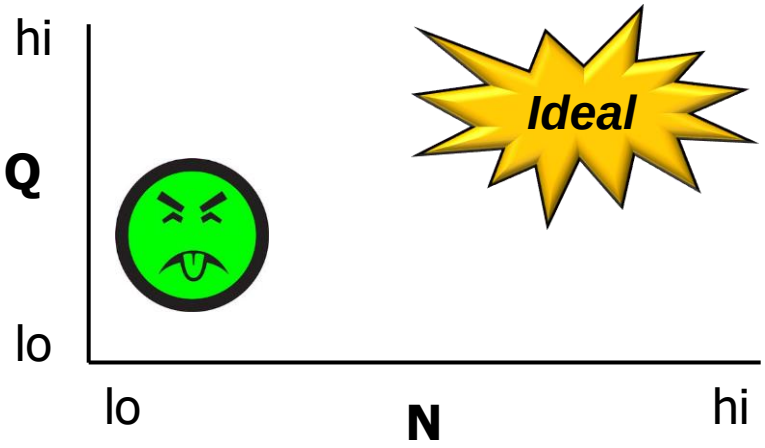
  - The startup costs of parallelism overwhelm the amount of data




```
class ParallelStreamFactorial {
  BigInteger factorial(long n) {
    return LongStream
      .rangeClosed(1, n)
      .parallel() ...
      .reduce(BigInteger.ONE,
              BigInteger::multiply);
  ...

class SequentialStreamFactorial {
  BigInteger factorial(long n) {
    return LongStream
      .rangeClosed(1, n) ...
      .reduce(BigInteger.ONE,
              BigInteger::multiply);
  ...
```

See previous lesson on "*When to Use Parallel Streams*"

When Not to Use Java Parallel Streams

- Parallel streams aren't suitable for certain types of programs, e.g.
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  - The startup costs of parallelism overwhelm the amount of data

The overhead of creating a parallel stream is > than the benefits of parallelism for small values of 'n'

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class SequentialStreamFactorial {
  BigInteger factorial(long n) {
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      .rangeClosed(1, n) ...
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  ...
```

See github.com/douglascraigschmidt/LiveLessons/tree/master/Java8/ex16

When Not to Use Java Parallel Streams

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If n is small then this parallel solution will be inefficient

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class ParallelStreamFactorial {
  BigInteger factorial(long n) {
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  ...

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  BigInteger factorial(long n) {
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      .rangeClosed(1, n) ...
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              BigInteger::multiply);
  ...
```

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  - The startup costs of parallelism overwhelm the amount of data

If n is small then this sequential solution will be more efficient

```
class ParallelStreamFactorial {
  BigInteger factorial(long n) {
    return LongStream
      .rangeClosed(1, n)
      .parallel() ...
      .reduce(BigInteger.ONE,
              BigInteger::multiply);
...

class SequentialStreamFactorial {
  BigInteger factorial(long n) {
    return LongStream
      .rangeClosed(1, n) ...
      .reduce(BigInteger.ONE,
              BigInteger::multiply);
...
```

When Not to Use Java Parallel Streams

- Parallel streams aren't suitable for certain types of programs, e.g.
  - The source is expensive to split or splits unevenly
  - The startup costs of parallelism overwhelm the amount of data
  - Combining partial results is costly

```
List<CharSequence> allWords =
  new ArrayList<>
    (TestDataFactory.getInput
       (sSHAKESPEARE_DATA_FILE,
        "\\s+"));
...

Set<CharSequence> uniqueWords =
  allWords
    .parallelStream()
    ...
    .collect(toCollection
                  (TreeSet::new));
```

See github.com/douglascraigschmidt/LiveLessons/tree/master/Java8/ex14

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Set<CharSequence> uniqueWords =
  allWords
    .parallelStream()
    ...
    .collect(toCollection
                  (TreeSet::new));
```

An array list of all words in the complete works of Shakespeare

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...

Set<CharSequence> uniqueWords =
  allWords
    .parallelStream()
    ...
    .collect(toCollection
                  (TreeSet::new));
```

Performance will be poor due to the overhead of combining partial results for a set in a parallel stream

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Set<CharSequence> uniqueWords =
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    .parallelStream()
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    .collect(toCollection
                  (TreeSet::new));
```

Combining costs can be alleviated if the amount of work performed per element is large (i.e., the "NQ model")

See developer.ibm.com/articles/j-java-streams-5-brian-goetz

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Set<CharSequence> uniqueWords =
  allWords
    .parallelStream()
    ...
    .collect(toSet()));
```

A concurrent collector can also be used to optimize the reduction phase

See Java8/ex14/src/main/java/utils/ConcurrentHashSetCollector.java

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```
Starting collector tests for 100000 words..printing results
   219 msecs: parallel timeStreamCollectToConcurrentSet()
   364 msecs: parallel timeStreamCollectToSet()
   657 msecs: sequential timeStreamCollectToSet()
   804 msecs: sequential timeStreamCollectToConcurrentSet()
Starting collector tests for 883311 words..printing results
  1782 msecs: parallel timeStreamCollectToConcurrentSet()
  3010 msecs: parallel timeStreamCollectToSet()
  6169 msecs: sequential timeStreamCollectToSet()
  7652 msecs: sequential timeStreamCollectToConcurrentSet()
```

```
List<CharSequence> allWords =
  new ArrayList<>
    (TestDataFactory.getInput
       (sSHAKESPEARE_DATA_FILE,
        "\\s+"));
...

Set<CharSequence> uniqueWords =
  allWords
    .parallelStream()
    ...
    .collect(toSet()));
```

Concurrent collector scales much better than non-concurrent collector

See previous earlier lesson on "*Java Parallel Stream Internals: Demo'ing Collector Performance*"

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  - Combining partial results is costly
  - Some streams operations don't sufficiently exploit parallelism

```
List<Double> result = Stream
   .iterate(2, i -> i + 1)
   .parallel()
   .filter(this::isEven)
   .limit(n)
   .map(this::findSQRT)
   .collect(toList());

List<Double> result = LongStream
   .range(2, (n * 2) + 1)
   .parallel()
   .filter(this::isEven)
   .mapToObj(this::findSQRT)
   .collect(toList());
```

See github.com/douglascraigschmidt/LiveLessons/tree/master/Java8/ex15

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Create a list containing sqrt of the first 'n' even numbers

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List<Double> result = Stream
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```

Stream.iterate() & limit() split & parallelize poorly since iterate creates an ordered stream…

See www.java2novice.com/java-8/streams/limit-method-example

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LongStream.range() splits nicely & thus runs efficiently in parallel

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List<Double> result = LongStream
   .range(2, (n * 2) + 1)
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  - Some streams operations don't sufficiently exploit parallelism
  - There aren't many/any cores

Older computing devices just have a single core, which limits available parallelism

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  - There aren't many/any cores
  - No built-in means to shutdown processing of a parallel stream

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  - No built-in means to shutdown processing of a parallel stream

```
private static volatile
  boolean mCancelled;
```

Define a static volatile flag

```
Image downloadImage(Cache.Item
                    item) {
  if (mCancelled)
    throw new
      CancellationException
        ("Canceling crawl.");
  ...
```

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private static volatile
  boolean mCancelled;
```

```
Image downloadImage(Cache.Item
                    item) {
  if (mCancelled)
    throw new
      CancellationException
        ("Canceling crawl.");
  ...
```

Before downloading the next image, check for cancellation & throw an exception if cancelled

End of Learn When Not to Use Java Parallel Streams