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
        - e.g., the source is expensive to split or splits unevenly, startup costs of parallelism are too high, combining partial results is costly, as well as when there aren't many cores

When Not to Use Java Parallel Streams

When Not to Use Java Parallel Streams

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

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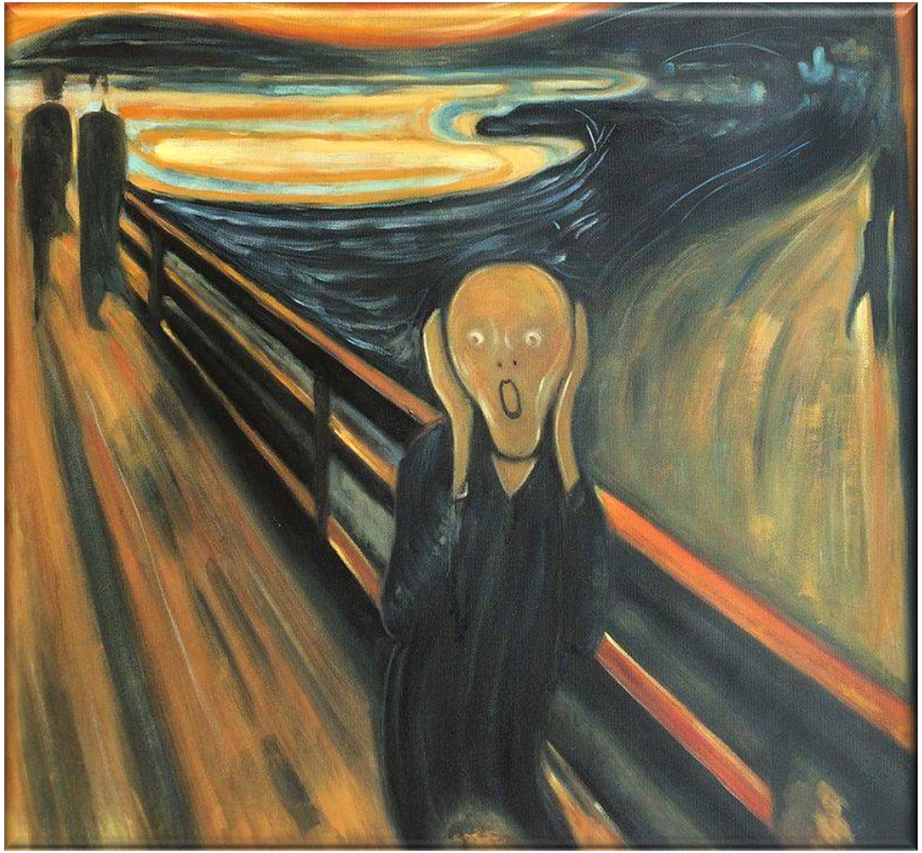

See developer.ibm.com/articles/j-java-streams-5-brian-goetz

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> arrayWords =
  TestDataFactory.getInput
    (sSHAKESPEARE_WORKS,
     sSPLIT_WORDS");

List<CharSequence> listWords =
  new LinkedList<>(arrayWords);

arrayWords.parallelStream()
              ...;

listWords.parallelStream()
             ...;
```

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

When Not to Use Java Parallel Streams

- Parallel streams aren't suitable for certain types of programs, e.g.
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Make an ArrayList that contains all words in the works of Shakespeare

```
List<CharSequence> arrayWords =
  TestDataFactory.getInput
    (sSHAKESPEARE_WORKS,
     sSPLIT_WORDS");

List<CharSequence> listWords =
  new LinkedList<>(arrayWords);

arrayWords.parallelStream()
              ...;

listWords.parallelStream()
             ...;
```

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```
List<CharSequence> arrayWords =
  TestDataFactory.getInput
    (sSHAKESPEARE_WORKS,
     sSPLIT_WORDS");

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

arrayWords.parallelStream()
              ...;

listWords.parallelStream()
             ...;
```

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

LinkedList doesn't split evenly or efficiently compared with ArrayList

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  TestDataFactory.getInput
    (sSHAKESPEARE_WORKS,
     sSPLIT_WORDS");

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

arrayWords.parallelStream()
              ...;

listWords.parallelStream()
              ...;
```

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

Starting spliterator tests for 910654
words....printing results
  5718 msecs: ArrayList parallel
 31226 msecs: LinkedList parallel
```

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 source is expensive to split or splits unevenly

```
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);
  }
  ...
```

The ArrayList spliterator runs in O(1) constant time

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

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

Compute the mid-point efficiently

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  ...
  ArrayListSpliterator<E>
    trySplit() {
    int hi = getFence(), lo =
      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

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

```
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

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  ...
  public Spliterator<E> trySplit(){
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    do { a[j++] = p.item; }
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    ...
    return Spliterators
      .spliterator(a, 0, j,
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```

Create a fixed-size chunk

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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);
```

Copy data into the chunk

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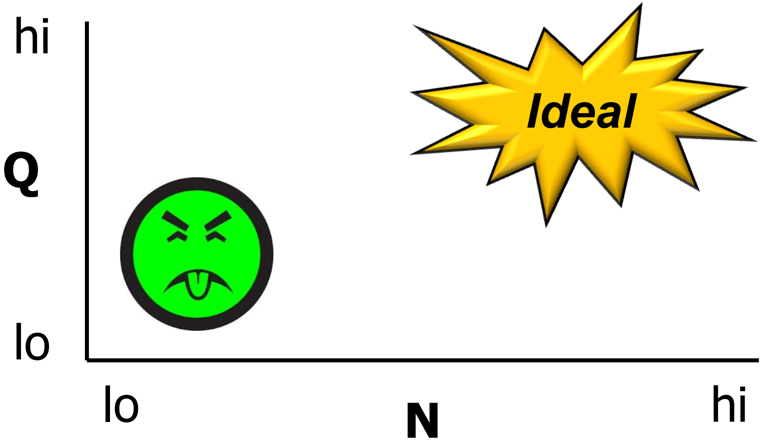
  ...
  public Spliterator<E> trySplit(){
    ...
    int n = batch + BATCH_UNIT;
    ...
    Object[] a = new Object[n];
    int j = 0;
    do { a[j++] = p.item; }
    while ((p = p.next) != null
           && j < n);
    ...
    return Spliterators
      .spliterator(a, 0, j,
                   Spliterator.ORDERED);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

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.
  - The source is expensive to split or splits unevenly
  - 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

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

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

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

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

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

If n is small then this parallel solution will be inefficient

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

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              BigInteger::multiply);
  ...

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

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

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> arrayWords =
  new ArrayList<>
    (TestDataFactory.getInput
       (sSHAKESPEARE_DATA_FILE,
        sSPLIT_WORDS));
...

collect
  .apply("non-concurrent "
          + testType,
         true,
         arrayWords,
         toCollection
           (setSupplier));
```

See github.com/douglascraigschmidt/LiveLessons/tree/master/Java8/ex36

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...

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          arrayWords,
          toCollection
            (setSupplier));
```

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

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  .apply("non-concurrent "
           + testType,
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         arrayWords,
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           (setSupplier));
```

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

In this case setSupplier is TreeSet::new

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  new ArrayList<>
    (TestDataFactory.getInput
       (sSHAKESPEARE_DATA_FILE,
        sSPLIT_WORDS));
...

collect
  .apply("non-concurrent "
          + testType,
         true,
         arrayWords,
         toCollection
           (setSupplier));
```

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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...

collect
   .apply("non-concurrent "
             + testType,
            true,
            arrayWords,
            toCollection
              (setSupplier));
```

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

See docs.oracle.com/javase/8/docs/api/java/util/concurrent/ConcurrentHashMap.html#newKeySet

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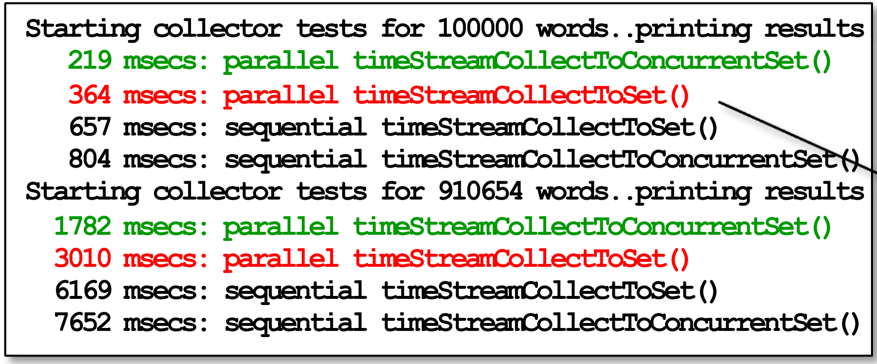

```
Starting collector tests for 100000 words..printing results
   219 msecs: parallel timeStreamCollectToConcurrentSet()
   364 msecs: parallel timeStreamCollectToSet()
   657 msecs: sequential timeStreamCollectToSet()
   804 msecs: sequential timeStreamCollectToConcurrentSet()
Starting collector tests for 910654 words..printing results
  1782 msecs: parallel timeStreamCollectToConcurrentSet()
  3010 msecs: parallel timeStreamCollectToSet()
  6169 msecs: sequential timeStreamCollectToSet()
  7652 msecs: sequential timeStreamCollectToConcurrentSet()
```

```
List<CharSequence> arrayWords =
  new ArrayList<>
    (TestDataFactory.getInput
       (sSHAKESPEARE_DATA_FILE,
        sSPLIT_WORDS));
...

collect
  .apply("non-concurrent "
          + testType,
         true,
         arrayWords,
         toCollection
```

Concurrent collector may scale much better than non-concurrent collector

See previous earlier lesson on “*Java Parallel Stream Internals: Demo’ing Collector Performance*”

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- 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
  - 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)
   .toList();

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

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

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   .toList();
```

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

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List<Double> result = Stream
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   .parallel()
   .filter(this::isEven)
   .limit(n)
   .map(this::findSQRT)
   .toList();
```

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

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

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

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   .toList();
```

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List<Double> result = LongStream
   .range(2, (n * 2) + 1)
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   .filter(this::isEven)
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```

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

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```

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

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

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
  - Combining partial results is costly
  - Some streams operations don't sufficiently exploit parallelism
  - There aren't many cores

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

When Not to Use Java Parallel Streams

- Also be aware that there is no built-in means to shutdown processing of a parallel stream

See video.disney.com/watch/sorcerer-s-apprentice-fantasia-4ea9ebc01a74ea59a5867853

When Not to Use Java Parallel Streams

- Also be aware that there is 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.");
  ...
```

When Not to Use Java Parallel Streams

- Also be aware that there is no built-in means to shutdown processing of a parallel stream

```
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 When Not to Use Java Parallel Streams