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

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

arrayAllWords.parallelStream()
  ...

listAllWords.parallelStream()
  ...;

Make an ArrayList that contains all words in the works of Shakespeare
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List<CharSequence> arrayAllWords = 
    TestDataFactory.getInput(sSHAKESPEARE_WORKS, "\s+");

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

arrayAllWords.parallelStream()
    ...;

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

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

LinkedList doesn’t split evenly or efficiently compared with ArrayList
When Not to Use Java Parallel Streams

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

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

arrayAllWords.parallelStream();

listAllWords.parallelStream();
```

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

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

See earlier lesson on “Java Parallel Stream Internals: Demo’ing Spliterator Performance”
When Not to Use Java Parallel Streams

- Parallel streams aren’t suitable for certain types of programs, e.g.
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The ArrayList spliterator runs in O(1) constant time

```java
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](openjdk/8u40-b25/java/util/ArrayList.java)
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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);
    }
    ...
}
```

*Compute the mid-point efficiently*
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```
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);
    }
    ...
```

`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

```java
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](openjdk/8-b132/java/util/LinkedList.java)
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- The source is expensive to split or splits unevenly

```java
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, 
            Splitterator.ORDERED);
    }
}
```

Create a fixed-size chunk
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```java
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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```java
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);
    }
}
```

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

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

```java
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.
  - The source is expensive to split or splits unevenly
  - 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'

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
When Not to Use Java Parallel Streams

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

```java
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

```java
List<CharSequence> allWords = new ArrayList<>((TestdataFactory.getInput(sSHAKESPEARE_DATA_FILE, "\s+"));
...
Set<CharSequence> uniqueWords = allWords
  .parallelStream()
  ... .collect(toCollection(TreeSet::new));
```

See github.com/douglasraingschmidt/LiveLessons/tree/master/Java8/ex14
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  - 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));

An array list of all words in the complete works of Shakespeare
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```java
List<CharSequence> allWords =
    new ArrayList<>(
        TestDataFactory.getInput(sSHAKESPEARE_DATA_FILE, "\\s+"));

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

Set<CharSequence> uniqueWords =
    allWords
    .parallelStream()
    ... .collect(toCollection(TreeSet::new));
```
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        TestDataFactory.getInput(sSHAKESPEARE_DATA_FILE, "\s+"));
...
Set<CharSequence> uniqueWords =
    allWords
    .parallelStream()
    ...
    .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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List<CharSequence> allWords = new ArrayList<>(
  TestDataFactory.getInput(sSHAKESPEARE_DATA_FILE, "\s+"));

... 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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```java
List<CharSequence> allWords = new ArrayList<>(
    TestDataFactory.getInput("s+"));
...
Set<CharSequence> uniqueWords = allWords.parallelStream()
    .collect(toSet());
```

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()

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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  - 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

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

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

See [github.com/douglascraigschmidt/LiveLessons/tree/master/Java8/ex15](https://github.com/douglascraigschmidt/LiveLessons/tree/master/Java8/ex15)
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Create a list containing \(\sqrt{\text{the first } n\text{'even numbers}}\)

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

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

See [www.java2novice.com/java-8/streams/limit-method-example](www.java2novice.com/java-8/streams/limit-method-example)
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```

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

Create a list containing sqrt of the first 'n' even numbers
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  .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());

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

*Older computing devices just have a single core, which limits available parallelism*
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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/any cores
  - No built-in means to shutdown processing of a parallel stream
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  - There aren’t many/any cores
  - No built-in means to shutdown processing of a parallel stream

```java
private static volatile boolean mCancelled;

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

Define a static volatile flag
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  - No built-in means to shutdown processing of a parallel stream

```java
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