Avoiding Programming Hazards with Java Parallel Streams

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Learning Objectives in this Part of the Lesson

- Know how aggregate operations & functional programming features are applied in the parallel streams framework
- Be aware of how parallel stream phases work “under the hood”
- Recognize common programming hazards in Java parallel streams & how to avoid them

See earlier lesson on “Java Streams: Avoiding Common Programming Mistakes”
Avoiding Programming Hazards in Java Parallel Streams
Avoiding Programming Hazards in Java Parallel Streams

• The Java parallel streams framework assumes behaviors don’t incur race conditions

Race conditions arise when an app depends on the sequence or timing of threads for it to operate properly

See [en.wikipedia.org/wiki/Race_condition#Software](en.wikipedia.org/wiki/Race_condition#Software)
Avoiding Programming Hazards in Java Parallel Streams

- Thus avoid/minimize behaviors with side-effects in parallel streams
Avoiding Programming Hazards in Java Parallel Streams

- Thus avoid/minimize behaviors with side-effects in parallel streams, e.g.
  - **Stateful lambda expressions**
  - Where results depend on shared mutable state

```java
class BuggyFactorial {
    static class Total {
        long mTotal = 1;
        void mult(long n) {
            mTotal *= n;
        }
    }

    static long factorial(long n) {
        Total t = new Total();
        LongStream.rangeClosed(1, n)
            .parallel()
            .forEach(t::mult);
        return t.mTotal;
    }
}
```

See [docs.oracle.com/javase/8/docs/api/java/util/stream/package-summary.html#Statelessness](https://docs.oracle.com/javase/8/docs/api/java/util/stream/package-summary.html#Statelessness)
• Thus avoid/minimize behaviors with side-effects in parallel streams, e.g.
  • *Stateful lambda expressions*
  • Where results depend on shared mutable state
    • i.e., state that may change in parallel execution of a pipeline

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Incorrectly compute the factorial of param n using a parallel stream

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Define mutable state that’s shared between threads in parallel stream

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```
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  ```java
  class BuggyFactorial {
      static class Total {
          long mTotal = 1;
          void mult(long n) {
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          }
      }
      static long factorial(long n) {
          Total t = new Total();
          LongStream.rangeClosed(1, n)
              .parallel()
              .forEach(t::mult);
          return t.mTotal;
      }
  }
  ```

  **Race conditions & inconsistent memory visibility** may arise from the unsynchronized access to `mTotal` field.
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  • *Stateful lambda expressions*
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Using terminal operations like `reduce()` (or `collect()`) trivially addresses these problems!

```java
class ParallelFactorial {
    static long factorial(long n) {
        return LongStream
            .rangeClosed(1, n)
            .parallel()
            .reduce(1L,
                (x, y) -> x * y);
    }
    ...
}
```

See [github.com/douglasraigschmidt/LiveLessons/tree/master/Java8/ex16](https://github.com/douglasraigschmidt/LiveLessons/tree/master/Java8/ex16)
Avoiding Programming Hazards in Java Parallel Streams

- Thus avoid/minimize behaviors with side-effects in parallel streams, e.g.
  - **Stateful lambda expressions**
  - **Interference w/the data source**
    - Occurs when source of stream is modified within the pipeline

```
List<Integer> list = IntStream.range(0, 10)
    .boxed()
    .collect(toCollection(LinkedList::new));

list
    .parallelStream()
    .peek(list::remove)
    .forEach(System.out::println);
```

See docs.oracle.com/javase/8/docs/api/java/util/stream/package-summary.html#NonInterference
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Thus avoid/minimize behaviors with side-effects in parallel streams, e.g.

- **Stateful lambda expressions**
- **Interference w/the data source**
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    .range(0, 10)
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list
    .parallelStream()
    .peek(list::remove)
    .forEach(System.out::println);
```

Create a list of ten integers in range 0..9

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  • *Interference w/the data source*
    • Occurs when source of stream is modified within the pipeline

List<Integer> list = IntStream.range(0, 10).boxed().collect(toCollection(LinkedList::new));

list.parallelStream().peek(list::remove).forEach(System.out::println);

If a non-concurrent collection is modified while it’s being operated on by the parallel stream the results will be chao & insanity!!

See docs.oracle.com/javase/8/docs/api/java/util/stream/Stream.html#peek
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- Behaviors involving no shared state or side-effects are useful for parallel streams since they needn’t be synchronized explicitly

See henrikeichenhardt.blogspot.com/2013/06/why-shared-mutable-state-is-root-of-all.html
Avoiding Programming Hazards in Java Parallel Streams

- Behaviors involving no shared state or side-effects are useful for parallel streams since they needn’t be synchronized explicitly.
  
  - e.g., Java lambda expressions & method references that are “pure functions”

```java
return new SearchResults(
    Thread.currentThread().getId(),
    currentCycle(), phrase, title,
    StreamSupport.stream(new PhraseMatchSpliterator(input, phrase),
      parallel).
    collect(toList()));
```

return mList.size() == 0;

See en.wikipedia.org/wiki/Pure_function
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- If it’s necessary to access & update shared mutable state in a parallel stream make sure to synchronize it properly!

```java
mImageCache
```

- List of URLs to Download
  - `filter(not(this::urlCached))`
  - `map(this::blockingDownload)`
  - `flatMap(this::applyFilters)`
  - `collect(toList())`

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```java
List of URLs to Download
```

```java
mImageCache
```

```java
ConcurrentHashMap
```

See [docs.oracle.com/javase/8/docs/api/java/util/concurrent/ConcurrentHashMap.html](http://docs.oracle.com/javase/8/docs/api/java/util/concurrent/ConcurrentHashMap.html)
End of Avoiding Programming Hazards with Java Parallel Streams