Avoid 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 how to avoid programming hazards in parallel streams

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

- Parallel streams should therefore avoid behaviors with side-effects

See docs.oracle.com/javase/tutorial/collections/streams/parallelism.html#side_effects
Parallel streams should therefore avoid behaviors with side-effects, 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)
Parallel streams should therefore avoid behaviors with side-effects, 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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    static long factorial(long n) {
        Total t = new Total();
        LongStream.rangeClosed(1, n).parallel().forEach(t::mult);
        return t.mTotal;
    }

    // ... more code...
}
```

*Define mutable state that’s shared between threads in parallel stream*
Parallel streams should therefore avoid behaviors with side-effects, e.g.

- **Stateful lambda expressions**
  - Where results depend on shared mutable state
  - i.e., state that may change in parallel execution of a pipeline

Race conditions & inconsistent memory visibility may arise from the unsynchronized access to mTotal field
Parallel streams should therefore avoid behaviors with side-effects, e.g.

- Stateful lambda expressions
- Interference w/the data source
  - Occurs when source of stream is modified within the pipeline

See docs.oracle.com/javase/8/docs/api/java/util/stream/package-summary.html#NonInterference

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

```java
list
.parallelStream()
.peek(list::remove)
.forEach(System.out::println);
```
Avoiding Programming Hazards in Java Parallel Streams

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  - Stateful lambda expressions
  - Interference w/the data source
    - Occurs when source of stream is modified within the pipeline

```java
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  .boxed()
  .collect(toCollection(ArrayList::new));

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

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

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

```java
def list = IntStream.range(0, 10)  
  .boxed()  
  .collect(toCollection(ArrayList::new));
```

```java
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](https://docs.oracle.com/javase/8/docs/api/java/util/stream/Stream.html#peek)
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

See [henrikeichenhardt.blogspot.com/2013/06/why-shared-mutable-state-is-root-of-all.html](http://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”. See en.wikipedia.org/wiki/Pure_function

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

```
return mList.size() == 0;
```

Return 45,000+ phrases for Search Phrases.
Avoiding Programming Hazards in Java Parallel Streams

- If it’s necessary to access & update shared mutable state in a parallel stream make sure to synchronize it properly!

```
List of URLs to Download

mImageCache

0 1 2 n

Hash Bucket Hash Bucket Hash Bucket Hash Bucket

Segment Locks

filter(not(this::urlCached))

map(this::blockingDownload)

flatMap(this::applyFilters)

collect(toList())
```

Avoiding Programming Hazards in Java Parallel Streams

- If it’s necessary to access & update shared mutable state in a parallel stream make sure to synchronize it properly!

```java
filter(not(this::urlCached))
collect(toList())
```
End of Avoid Programming Hazards with Java Parallel Streams