Learn How Java Parallel Streams Work “Under the Hood”

Douglas C. Schmidt
d.schmidt@vanderbilt.edu
www.dre.vanderbilt.edu/~schmidt

Professor of Computer Science
Institute for Software Integrated Systems
Vanderbilt University
Nashville, Tennessee, USA
Learning Objectives in this Part of the Lesson

- Know how aggregate operations & functional programming features are applied in the parallel streams framework
- Learn how parallel stream phases work “under the hood”

See developer.ibm.com/articles/j-java-streams-3-brian-goetz
Overview of How a Parallel Stream Works
Overview of How a Parallel Stream Works

- A Java parallel stream implements a “map/reduce” variant optimized for multi-core processors.

See en.wikipedia.org/wiki/MapReduce
A Java parallel stream implements a “map/reduce” variant optimized for multi-core processors.

It’s actually a three phase “split-apply-combine” data processing strategy.

See www.jstatsoft.org/article/view/v040i01
Overview of How a Parallel Stream Works

- The split-apply-combine phases are:

  1. **Split** – Recursively partition a data source into “chunks”

```
trySplit()
```

```
CollectionData
```

```
trySplit()
```

```
CollectionData₁
```

```
CollectionData₁.₁
```

```
CollectionData₁.₂
```

```
CollectionData₂
```

```
CollectionData₂.₁
```

```
CollectionData₂.₂
```

---

Overview of How a Parallel Stream Works

- The split-apply-combine phases are:

  1. **Split** – Recursively partition a data source into “chunks”

    - **Split** – Recursively partition a data source into “chunks”
      - Each chunk is an independent & “atomic” subset of the data source

See upcoming lesson on “Java Parallel Stream Internals: Partitioning”
Overview of How a Parallel Stream Works

- The split-apply-combine phases are:

  1. **Split** – Recursively partition a data source into “chunks”

- Spliterators partition collections in Java

```java
public interface Spliterator<T> {
    boolean tryAdvance(Consumer<? Super T> action);
    Spliterator<T> trySplit();
    long estimateSize();
    int characteristics();
}
```

See [docs.oracle.com/javase/8/docs/api/java/util/Spliterator.html](https://docs.oracle.com/javase/8/docs/api/java/util/Spliterator.html)
Overview of How a Parallel Stream Works

- The split-apply-combine phases are:

  1. **Split** – Recursively partition a data source into “chunks”
  - Splitterators partition collections in Java

```java
public interface Spliterator<T> {
    boolean tryAdvance(Consumer<? Super T> action);
    Spliterator<T> trySplit();
    long estimateSize();
    int characteristics();
}
```

See [docs.oracle.com/javase/8/docs/api/java/util/Spliterator.html#tryAdvance](docs.oracle.com/javase/8/docs/api/java/util/Spliterator.html#tryAdvance)
Overview of How a Parallel Stream Works

- The split-apply-combine phases are:

  1. **Split** – Recursively partition a data source into “chunks”

- Spliterators partition collections in Java

```java
public interface Spliterator<T> {
    boolean tryAdvance(Consumer<? Super T> action);
    Spliterator<T> trySplit();
    long estimateSize();
    int characteristics();
}
```

Used only for parallel streams

See docs.oracle.com/javase/8/docs/api/java/util/Spliterator.html#trySplit
Overview of How a Parallel Stream Works

- The split-apply-combine phases are:

1. **Split** – Recursively partition a data source into “chunks”
   - Spliterators partition collections in Java
   - Each Java collection has a spliterator

```java
interface Collection<E> {
    ... 
    default Spliterator<E> spliterator() {
        return Spliterators.spliterator(this, 0);
    }

    default Stream<E> parallelStream() {
        return StreamSupport.stream(spliterator(), true);
    }
    ...
}
```

See [docs.oracle.com/javase/8/docs/api/java/util/Collection.html](docs.oracle.com/javase/8/docs/api/java/util/Collection.html)
The split-apply-combine phases are:

1. **Split** – Recursively partition a data source into “chunks”
   - Spliterators partition collections in Java
   - Each Java collection has a spliterator
   - Programmers can define custom spliterators

See [github.com/douglascraigschmidt/LiveLessons/tree/master/SearchStreamSpliterator](https://github.com/douglascraigschmidt/LiveLessons/tree/master/SearchStreamSpliterator)
The split-apply-combine phases are:

1. **Split** – Recursively partition a data source into “chunks”
   - Spliterators partition collections in Java
   - Each Java collection has a spliterator
   - Programmers can define custom spliterators
   - Parallel streams perform better on data sources that can be split efficiently & evenly

Overview of How a Parallel Stream Works

- The split-apply-combine phases are:

1. **Split** – Recursively partition a data source into “chunks”

2. **Apply** – Process chunks in a common thread pool

See lesson on “Java Parallel Stream Internals: Parallel Processing via the Common ForkJoinPool”
Overview of How a Parallel Stream Works

- The split-apply-combine phases are:

1. **Split** – Recursively partition a data source into “chunks”

2. **Apply** – Process chunks in a common thread pool

- Splitting & applying run simultaneously (after certain limits met), not sequentially.
Overview of How a Parallel Stream Works

- The split-apply-combine phases are:

1. **Split** – Recursively partition a data source into “chunks”

2. **Apply** – Process chunks in a common thread pool
   - Utilization’s maximized via “work-stealing”

See lesson on “Java Parallel Stream Internals: Mapping onto the Common ForkJoinPool”
Overview of How a Parallel Stream Works

- The split-apply-combine phases are:

  1. **Split** – Recursively partition a data source into “chunks”
  2. **Apply** – Process chunks in a common thread pool
    - Utilization’s maximized via “work-stealing”
    - Programmers can control # of threads in the pool

See lesson on “Java Parallel Stream Internals: Configuring the Common Fork-Join Pool”
Overview of How a Parallel Stream Works

• The split-apply-combine phases are:

1. Split – Recursively partition a data source into “chunks”

2. Apply – Process chunks in a common thread pool

3. Combine – Join partial results to a single result

See upcoming lessons on “Java Parallel Stream Internals: Combining Results”
Overview of How a Parallel Stream Works

- The split-apply-combine phases are:

1. **Split** – Recursively partition a data source into “chunks”

2. **Apply** – Process chunks in a common thread pool

3. **Combine** – Join partial results to a single result

   - Performed by terminal operations
   - e.g., collect() & reduce()

See [www.codejava.net/java-core/collections/java-8-stream-terminal-operations-examples](www.codejava.net/java-core/collections/java-8-stream-terminal-operations-examples)
Overview of How a Parallel Stream Works

- The split-apply-combine phases are:

1. **Split** – Recursively partition a data source into “chunks”
2. **Apply** – Process chunks in a common thread pool
3. **Combine** – Join partial results to a single result
   - Performed by terminal operations
   - Collectors can either be
     - Concurrent – synchronized
     - Non-concurrent – non-synchronized

See lessons on “Java Parallel Stream Internals: Non-Concurrent & Concurrent Collectors”
Overview of How a Parallel Stream Works

- The split-apply-combine phases are:

  1. **Split** – Recursively partition a data source into “chunks”
  2. **Apply** – Process chunks in a common thread pool
  3. **Combine** – Join partial results to a single result

• Performed by terminal operations

• Collectors can either be
  • Concurrent – synchronized
  • Non-concurrent – non-synchronized

Programmers can define custom collectors
End of Learn How Java Parallel Streams Work “Under the Hood”