Java Parallel Streams Internals: Non-Concurrent & Concurrent Collectors (Part 1)

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Learning Objectives in this Part of the Lesson

- Understand parallel stream internals, e.g.
  - Know what can change & what can’t
  - Partition a data source into “chunks”
  - Process chunks in parallel via the common fork-join pool
  - Configure the Java parallel stream common fork-join pool
  - Perform a reduction to combine partial results into a single result
- Recognize key behaviors & differences of non-concurrent & concurrent collectors
Overview of Concurrent & Non-Concurrent Collectors
Collector defines an interface whose implementations can accumulate input elements in a mutable result container.

Overview of Concurrent & Non-Concurrent Collectors

**Interface Collector**\(<T,A,R>\)

<table>
<thead>
<tr>
<th>Type Parameters:</th>
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<tbody>
<tr>
<td>T - the type of input elements to the reduction operation</td>
</tr>
<tr>
<td>A - the mutable accumulation type of the reduction operation (often hidden as an implementation detail)</td>
</tr>
<tr>
<td>R - the result type of the reduction operation</td>
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```java
public interface Collector\(<T,A,R>\)
```

A mutable reduction operation that accumulates input elements into a mutable result container, optionally transforming the accumulated result into a final representation after all input elements have been processed. Reduction operations can be performed either sequentially or in parallel.

Examples of mutable reduction operations include: accumulating elements into a Collection; concatenating strings using a StringBuilder; computing summary information about elements such as sum, min, max, or average; computing "pivot table" summaries such as "maximum valued transaction by seller", etc. The class Collectors provides implementations of many common mutable reductions.

A Collector is specified by four functions that work together to accumulate entries into a mutable result container, and optionally perform a final transform on the result. They are:

See [docs.oracle.com/javase/8/docs/api/java/util/stream/Collector.html](docs.oracle.com/javase/8/docs/api/java/util/stream/Collector.html)
Collector implementations can either be concurrent or non-concurrent based on their characteristics.

See docs.oracle.com/javase/8/docs/api/java/util/stream/Collector.Characteristics.html
Overview of Concurrent & Non-Concurrent Collectors

• Collector implementations can either be concurrent or non-concurrent based on their characteristics
• This distinction is only relevant for *parallel* streams

See "Java Streams: Introducing Non-Concurrent Collectors"
Overview of Concurrent & Non-Concurrent Collectors

• Collector implementations can either be concurrent or non-concurrent based on their characteristics
  • This distinction is only relevant for parallel streams
  • A non-concurrent collector can be used for either a sequential stream or a parallel stream!

We just focus on parallel streams in this lesson
Structure & Functionality of Non-Concurrent Collectors
Structure & Functionality of Non-Concurrent Collectors

A non-concurrent collector operates by merging sub-results

See stackoverflow.com/questions/22350288/parallel-streams-collectors-and-thread-safety
Structure & Functionality of Non-Concurrent Collectors

- A non-concurrent collector operates by merging sub-results
- The input is partitioned into chunks
A non-concurrent collector operates by merging sub-results

- The input is partitioned into chunks
- Each chunk runs in parallel in the common fork-join pool
Structure & Functionality of Non-Concurrent Collectors

- A non-concurrent collector operates by merging sub-results
  - The input is partitioned into chunks
  - Each chunk runs in parallel in the common fork-join pool
- Chunk sub-results are collected into an intermediate mutable result container
  - e.g., List, Set, Map, etc.
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Different threads operate on different instances of intermediate result containers.
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  - The input is partitioned into chunks
  - Each chunk runs in parallel in the common fork-join pool
  - Chunk sub-results are collected into an intermediate mutable result container
- Sub-results are merged into one mutable result container
A non-concurrent collector operates by merging sub-results

- The input is partitioned into chunks
- Each chunk runs in parallel in the common fork-join pool
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- Sub-results are merged into one mutable result container
  - Only one thread in the fork-join pool is used to merge any pair of intermediate sub-results
A non-concurrent collector operates by merging sub-results

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- Each chunk runs in parallel in the common fork-join pool
- Chunk sub-results are collected into an intermediate mutable result container
- Sub-results are merged into one mutable result container
  - Only one thread in the fork-join pool is used to merge any pair of intermediate sub-results

Thus there’s no need for any synchronizers in a non-concurrent collector
A non-concurrent collector operates by merging sub-results

- The input is partitioned into chunks
- Each chunk runs in parallel in the common fork-join pool
- Chunk sub-results are collected into an intermediate mutable result container

Sub-results are merged into one mutable result container

This process is safe & order-preserving, but costly for containers like maps & sets
Structure & Functionality of Concurrent Collectors
Structure & Functionality of Concurrent Collectors

- A concurrent collector creates one concurrent mutable result container & accumulates elements into it from multiple threads in a parallel stream.

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Structure & Functionality of Concurrent Collectors

- A concurrent collector creates one concurrent mutable result container & accumulates elements into it from multiple threads in a parallel stream
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- A concurrent collector creates one concurrent mutable result container & accumulates elements into it from multiple threads in a parallel stream
- As usual, the input is partitioned into chunks
- Each chunk runs in parallel in the common fork-join pool

![Diagram of concurrent collector process]

A concurrent collector creates one concurrent mutable result container & accumulates elements into it from multiple threads in a parallel stream.

- As usual, the input is partitioned into chunks.
- Each chunk runs in parallel in the common fork-join pool.
A concurrent collector creates one concurrent mutable result container & accumulates elements into it from multiple threads in a parallel stream

- As usual, the input is partitioned into chunks
- Each chunk runs in parallel in the common fork-join pool
- Chunk sub-results are collected into one mutable result container
- e.g., a concurrent collection

See [docs.oracle.com/javase/tutorial/essential/concurrency/collections.html](http://docs.oracle.com/javase/tutorial/essential/concurrency/collections.html)
Structure & Functionality of Concurrent Collectors

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Different threads in a parallel stream share one concurrent result container
A concurrent collector creates one concurrent mutable result container & accumulates elements into it from multiple threads in a parallel stream.

As usual, the input is partitioned into chunks.

Each chunk runs in parallel in the common fork-join pool.

Chunk sub-results are collected into one mutable result container.

Thus there’s no need to merge any intermediate sub-results!

Of course, encounter order is not preserved & synchronization is required.
A concurrent collector may out-perform a non-concurrent collector if merging costs are higher than synchronization costs.
Structure & Functionality of Concurrent Collectors

• A concurrent collector *may* out-perform a non-concurrent collector *if* merging costs are higher than synchronization costs.

• Highly optimized result containers like ConcurrentHashMap may be more efficient than merging HashMaps.

See codepumpkin.com/hashtable-vs-synchronizedmap-vs-concurrenthashmap
Structure & Functionality of Concurrent Collectors

- A concurrent collector *may* out-perform a non-concurrent collector *if* merging costs are higher than synchronization costs.
- Highly optimized result containers like ConcurrentHashMap may be more efficient than merging HashMaps.
- ConcurrentHashMap is also more efficient than a SynchronizedMap.

**Contention is low due to use of multiple locks**

Structure & Functionality of Concurrent Collectors

- A concurrent collector *may* out-perform a non-concurrent collector *if* merging costs are higher than synchronization costs
- Highly optimized result containers like ConcurrentHashMap may be more efficient than merging HashMaps
- ConcurrentHashMap is also more efficient than a SynchronizedMap

In contrast, SynchronizedMap uses just one lock

End of Java Parallel Streams Internals: Non-Concurrent & Concurrent Collectors (Part 1)