An Overview of Parallelism & Java Parallel Streams

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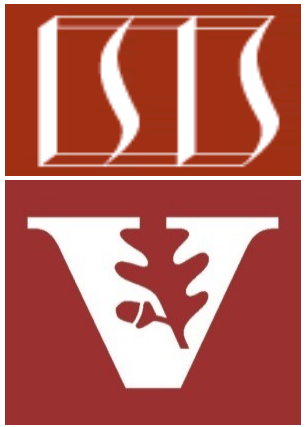

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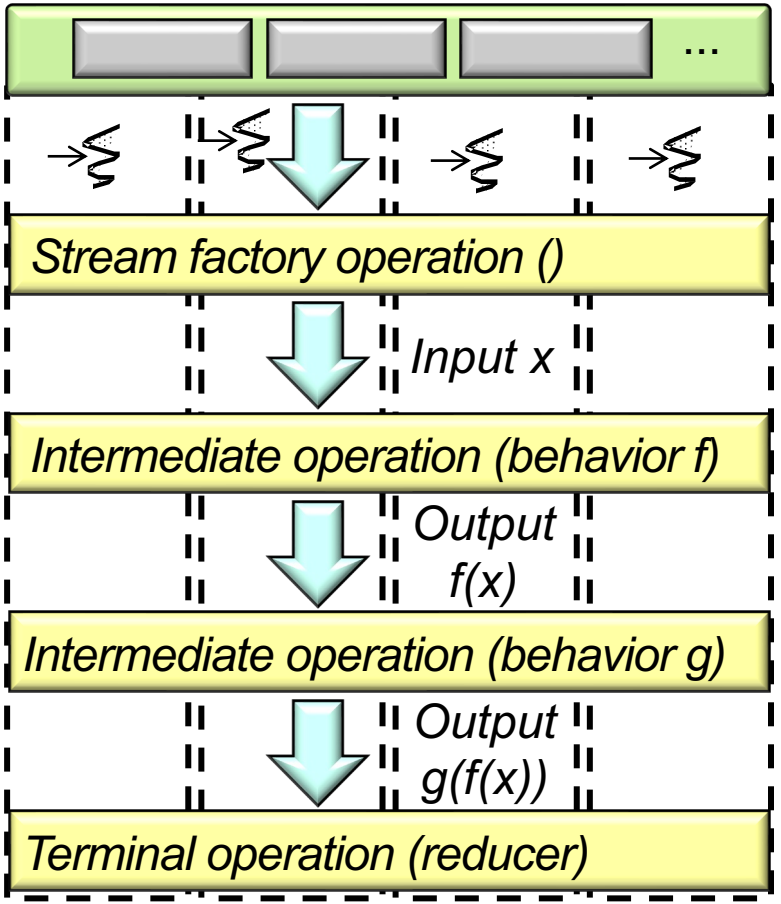
Learning Objectives in this Part of the Lesson

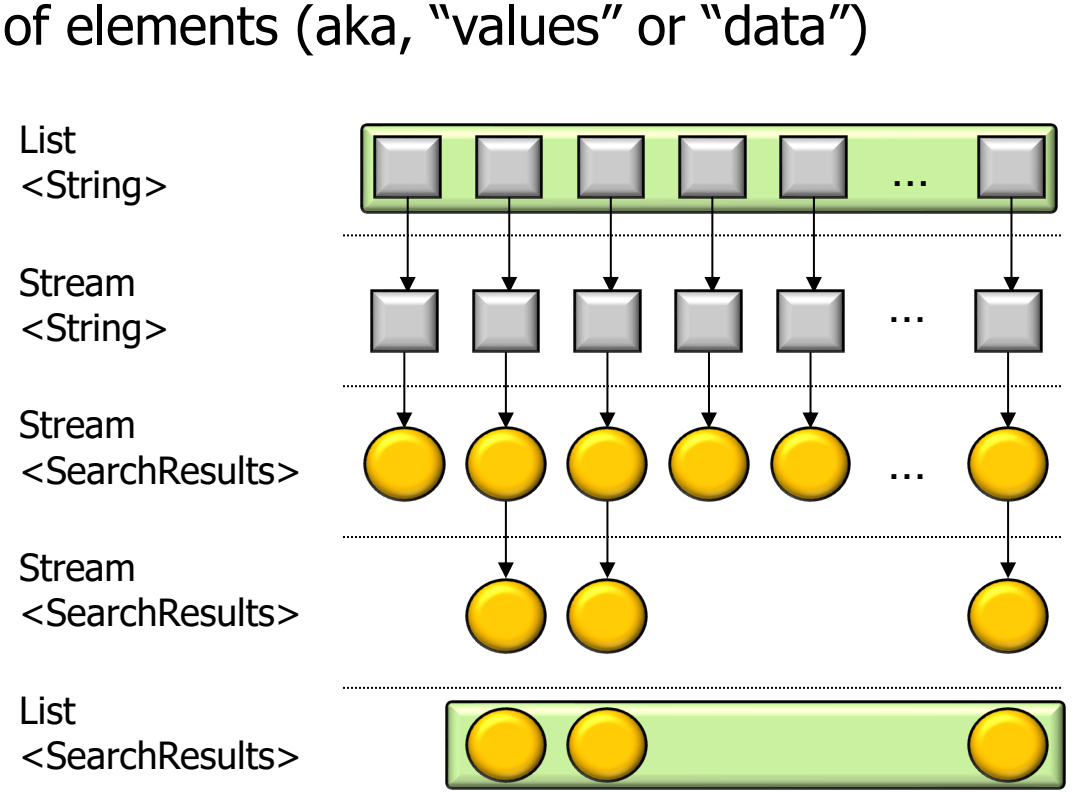
- Know how aggregate operations from Java sequential streams are applied seamlessly in the Java parallel streams framework

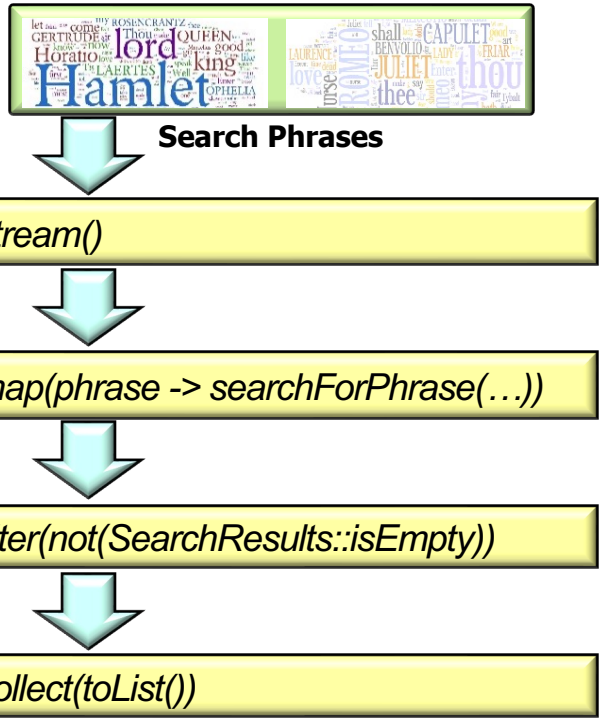


Transitioning from Sequential Streams to Parallel Streams

Transitioning from Sequential Streams to Parallel Streams

- A Java stream is a pipeline of aggregate operations that process a sequence of elements (aka, "values" or "data")





See github.com/douglascraigschmidt/LiveLessons/tree/master/SearchStreamGang

Transitioning from Sequential Streams to Parallel Streams

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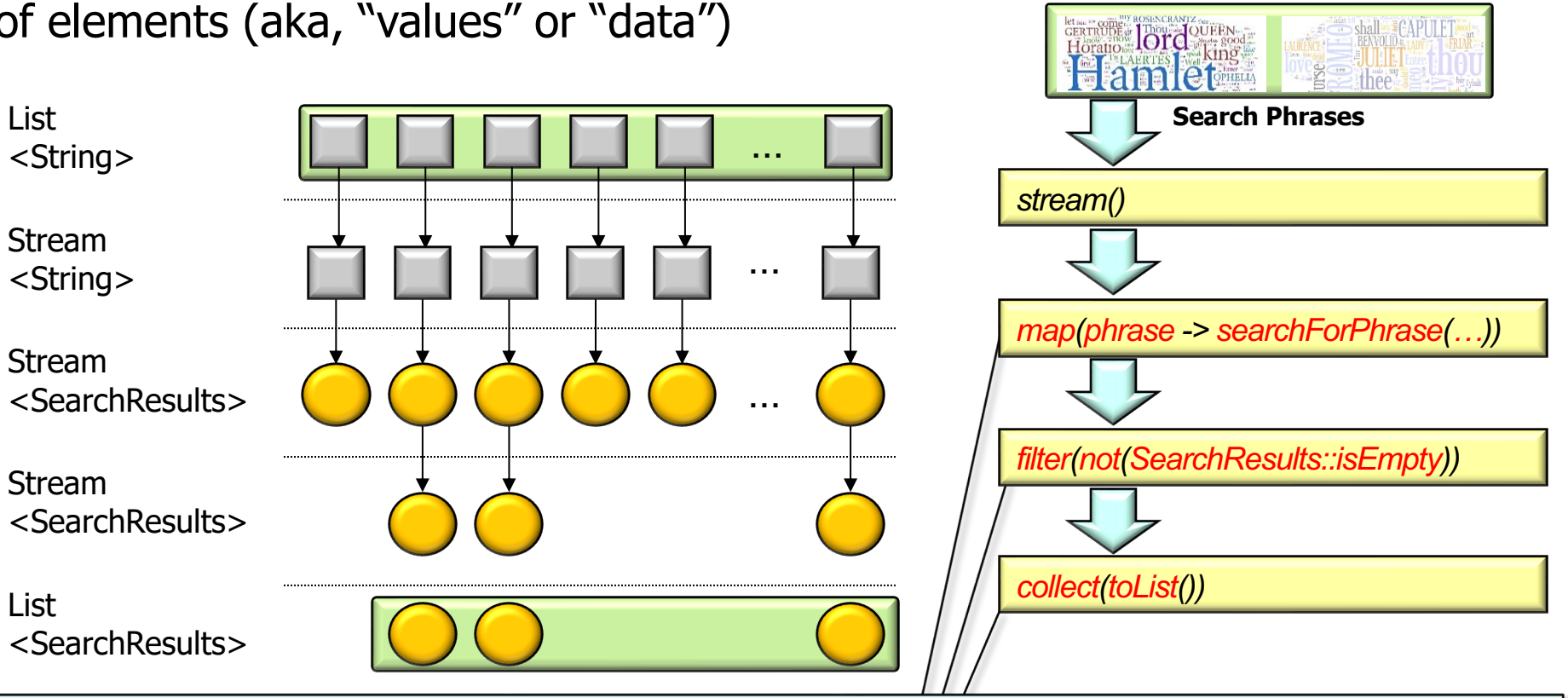
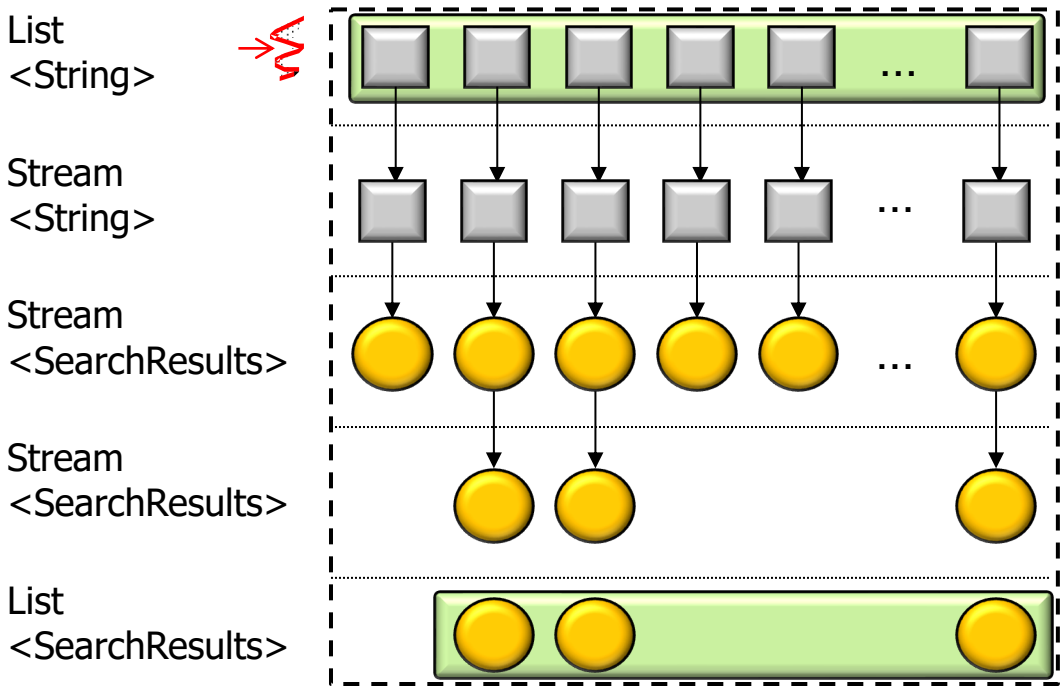
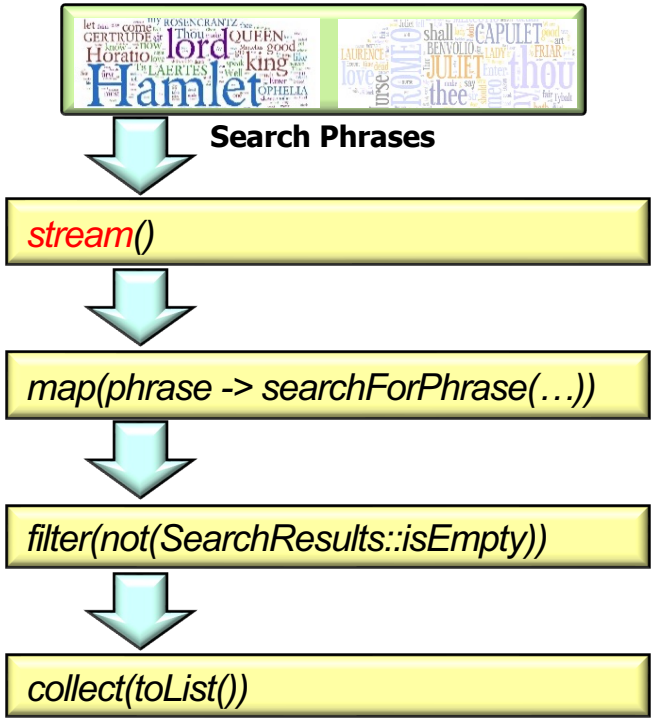


Aggregate operations use internal iteration & behaviors to process elements in a stream

Transitioning from Sequential Streams to Parallel Streams

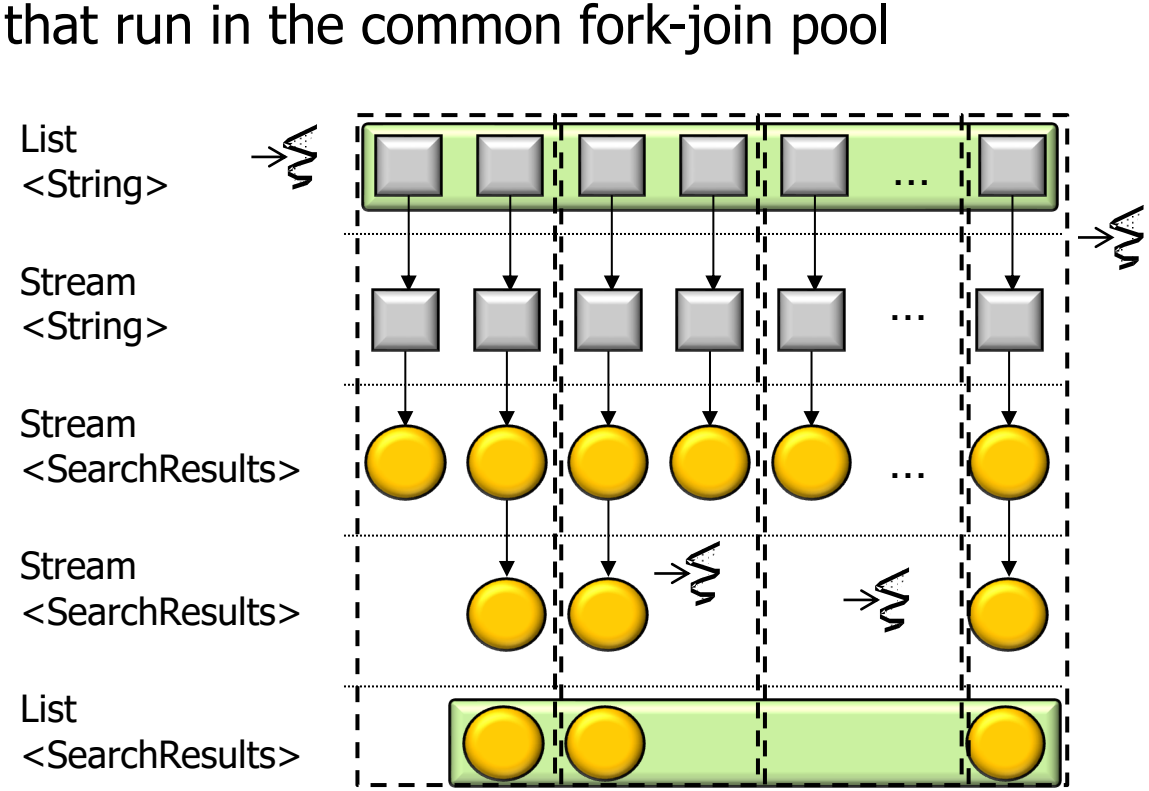
- By default, a stream executes sequentially, so all its aggregate operations run behaviors in a single thread of control

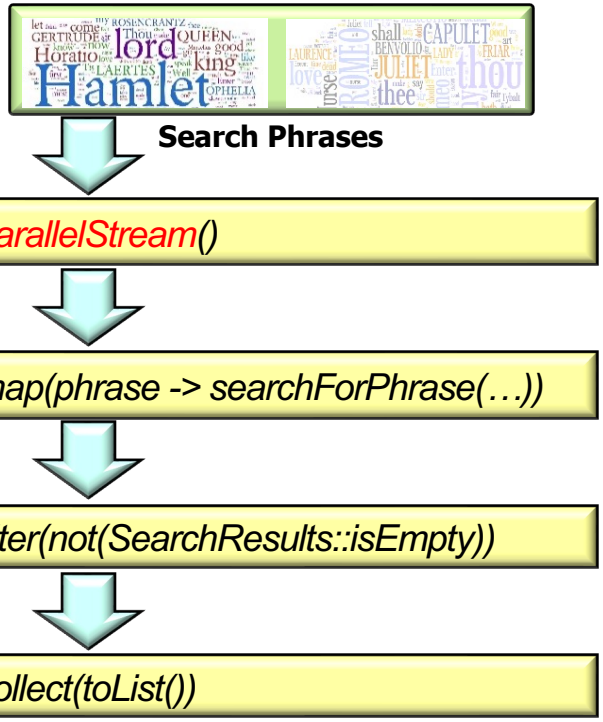




Transitioning from Sequential Streams to Parallel Streams

- When a stream executes in parallel, it is partitioned into multiple "chunks" that run in the common fork-join pool





See docs.oracle.com/javase/8/docs/api/java/util/concurrent/ForkJoinPool.html

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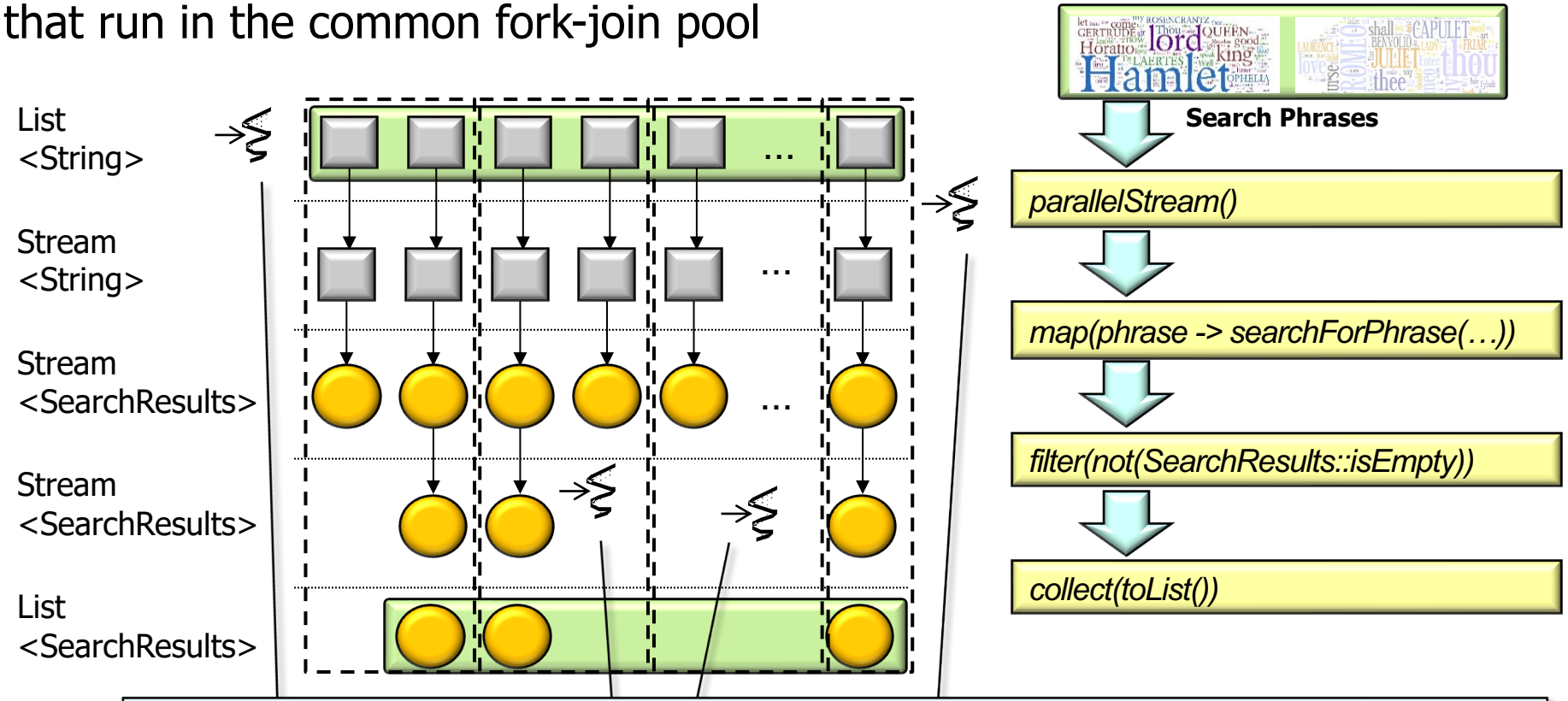

Threads in the fork-join pool (non-deterministically) process different chunks

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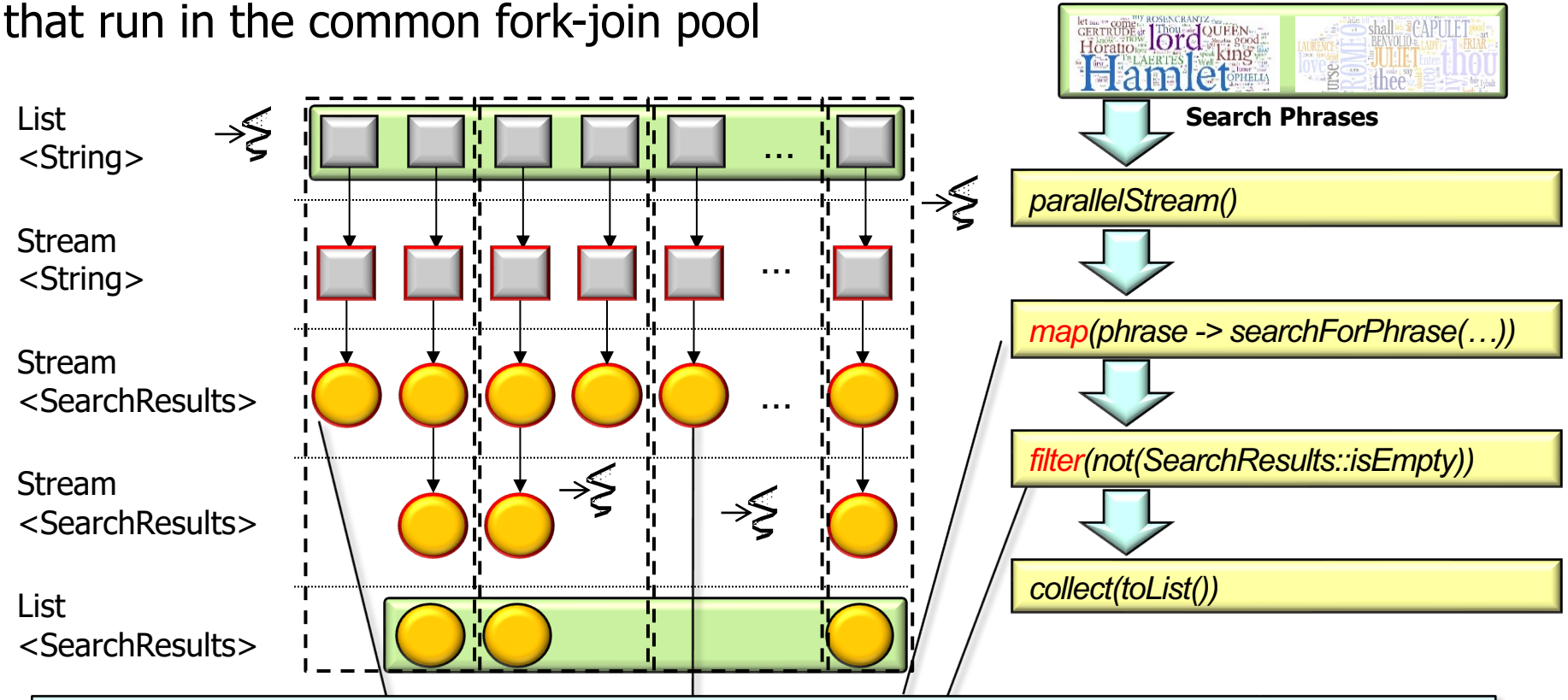

Intermediate operations cleverly process behaviors on these chunks in parallel

Transitioning from Sequential Streams to Parallel Streams

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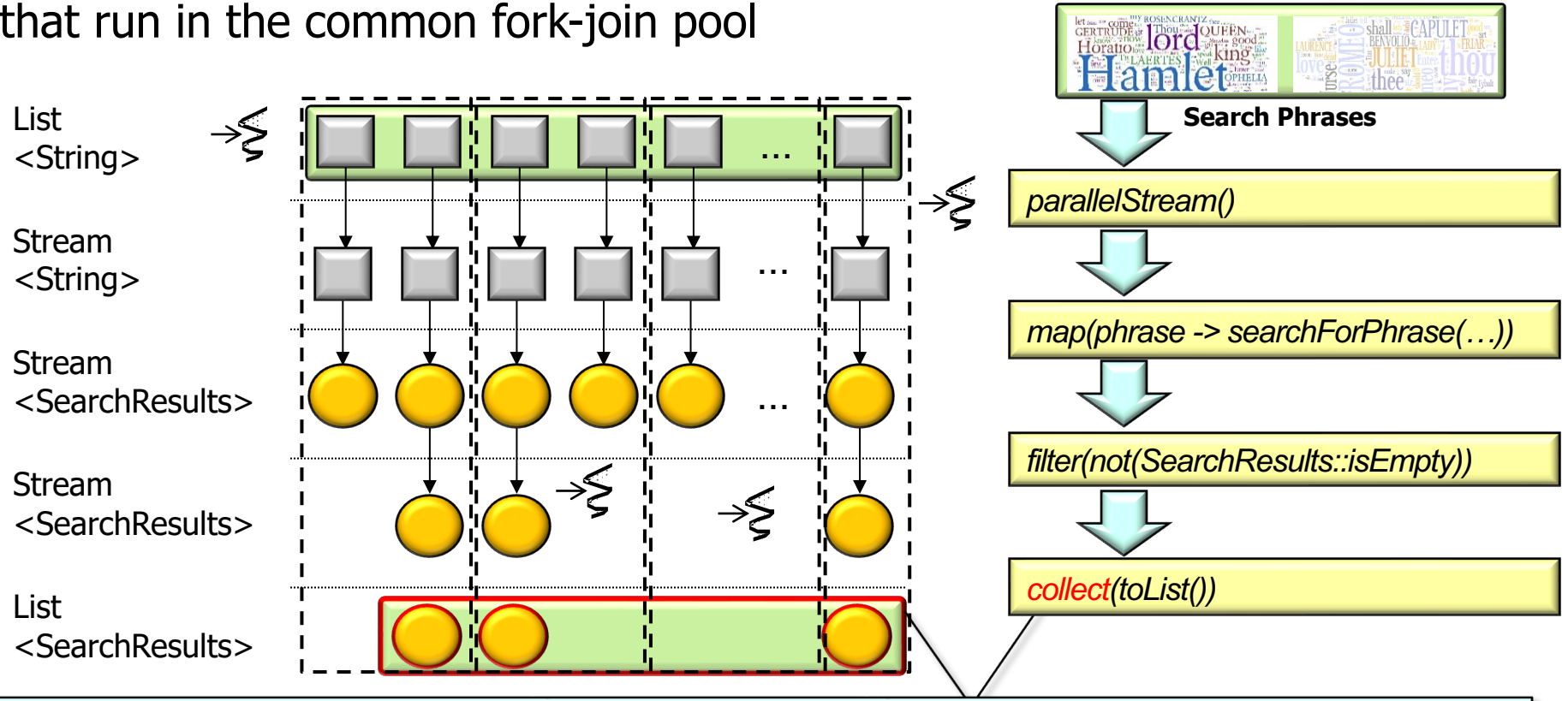

A terminal operation triggers processing & combines the chunks into a single result

Transitioning from Sequential Streams to Parallel Streams

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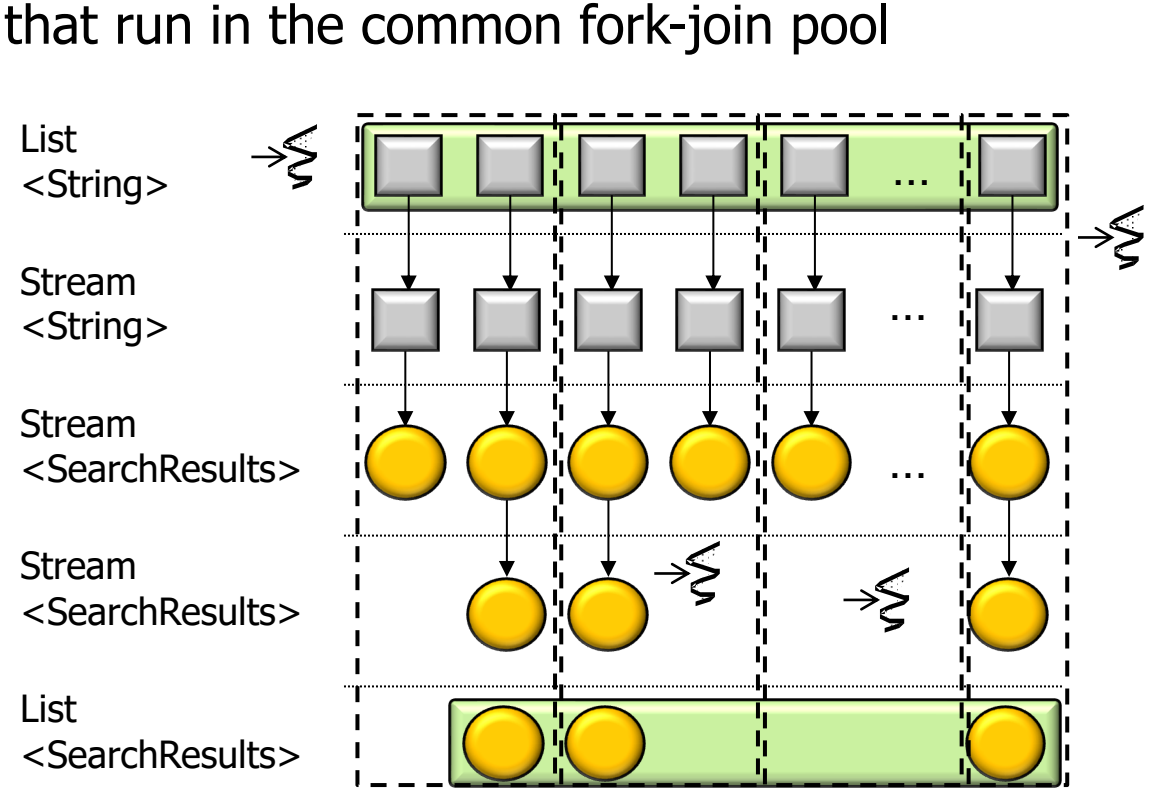

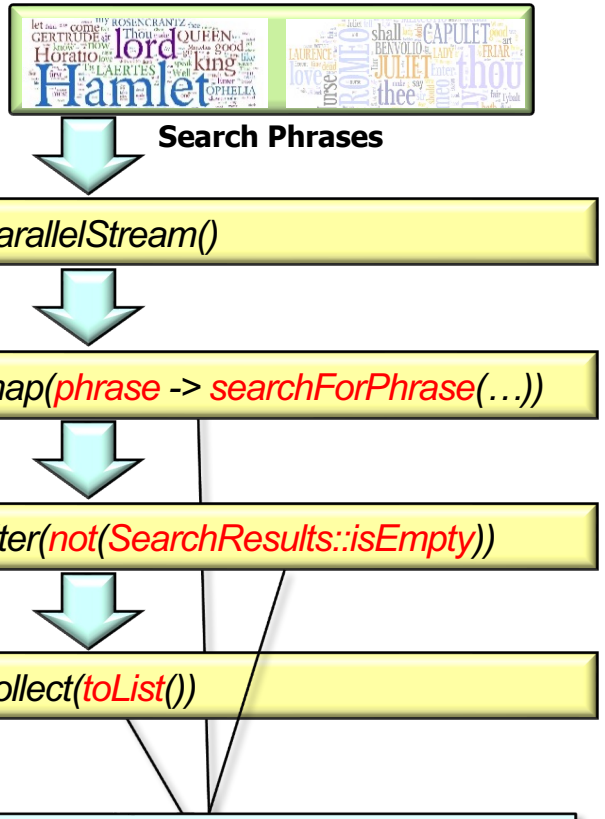

(Stateless) Java lambda expressions & method references are used to pass behaviors

Transitioning from Sequential Streams to Parallel Streams

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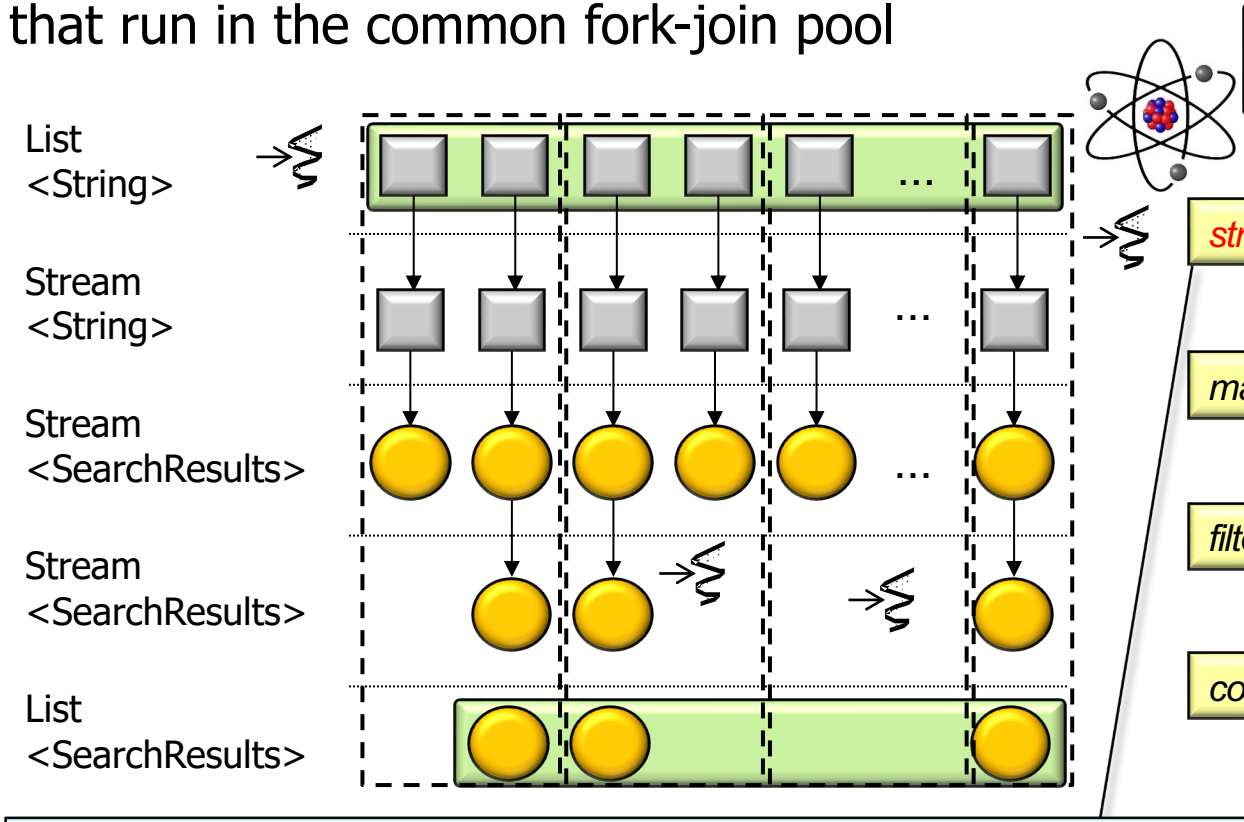


Search Phrases

stream() vs. parallelStream()

map(phrase -> searchForPhrase(…))

filter(not(SearchResults::isEmpty))

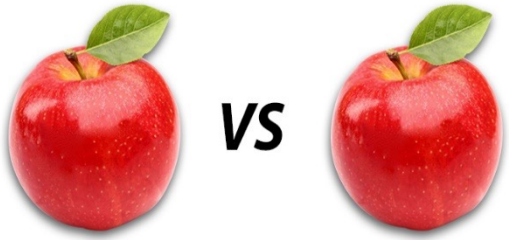
collect(toList())

Ideally, minuscule changes are needed to transition from sequential to parallel stream

Transitioning from Sequential Streams to Parallel Streams

- The same aggregate operations can be used for sequential & parallel streams

Modifier and Type	Method and Description
boolean	**allMatch**(**Predicate**<? super T> predicate) Returns whether all elements of this stream match the provided predicate.
boolean	**anyMatch**(**Predicate**<? super T> predicate) Returns whether any elements of this stream match the provided predicate.
static <T> **Stream.Builder**<T>	**builder**() Returns a builder for a Stream.
<R,A> R	**collect**(**Collector**<? super T,A,R> collector) Performs a **mutable reduction** operation on the elements of this stream using a Collector.
<R> R	**collect**(**Supplier**<R> supplier, **BiConsumer**<R,? super T> accumulator, **BiConsumer**<R,R> combiner) Performs a **mutable reduction** operation on the elements of this stream.
static <T> **Stream**<T>	**concat**(**Stream**<? extends T> a, **Stream**<? extends T> b) Creates a lazily concatenated stream whose elements are all the elements of the first stream followed by all the elements of the second stream.
long	**count**() Returns the count of elements in this stream.
Stream<T>	**distinct**() Returns a stream consisting of the distinct elements (according to **Object.equals(Object)**) of this stream.
static <T> **Stream**<T>	**empty**() Returns an empty sequential Stream.
Stream<T>	**filter**(**Predicate**<? super T> predicate) Returns a stream consisting of the elements of this stream that match the given predicate.
Optional<T>	**findAny**() Returns an **Optional** describing some element of the stream, or an empty Optional if the stream is empty.
Optional<T>	**findFirst**() Returns an **Optional** describing the first element of this stream, or an empty Optional if the stream is empty.
<R> **Stream**<R>	**flatMap**(**Function**<? super T,? extends **Stream**<? extends R>> mapper) Returns a stream consisting of the results of replacing each element of this stream with the contents of a mapped stream produced by applying the provided mapping function to each element.



See docs.oracle.com/javase/8/docs/api/java/util/stream/Stream.html

Transitioning from Sequential Streams to Parallel Streams

- The same aggregate operations can be used for sequential & parallel streams

e.g., SearchStreamGang uses the same aggregate operations for both SearchWithSequentialStreams & SearchWithParallelStreams implementations

stream() vs. parallelStream()

map(phrase -> searchForPhrase(…))

filter(not(SearchResults::isEmpty))

collect(toList())

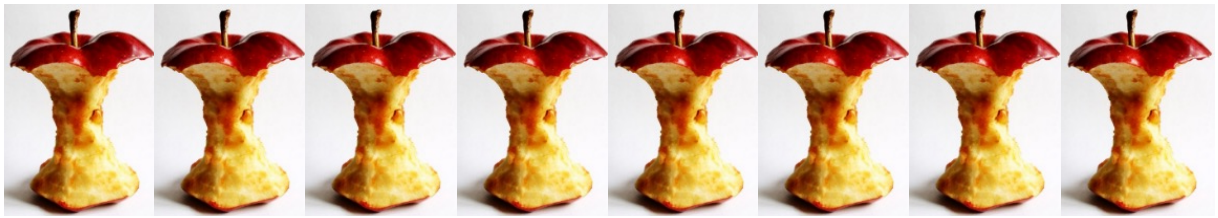
<<Java Class>>
SearchWithSequentialStreams
- processStream():List<List<SearchResults>>
- processInput(String):List<SearchResults>

<<Java Class>>
SearchWithParallelStreams
- processStream():List<List<SearchResults>>
- processInput(CharSequence):List<SearchResults>

See github.com/douglascraigschmidt/LiveLessons/tree/master/SearchStreamGang

Transitioning from Sequential Streams to Parallel Streams

- The same aggregate operations can be used for sequential & parallel streams
  - Java streams can thus treat parallelism as an optimization & leverage all available cores!



Search Phrases

parallelStream()

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See qconlondon.com/london-2017/system/files/presentation-slides/concurrenttoparallel.pdf

Transitioning from Sequential Streams to Parallel Streams

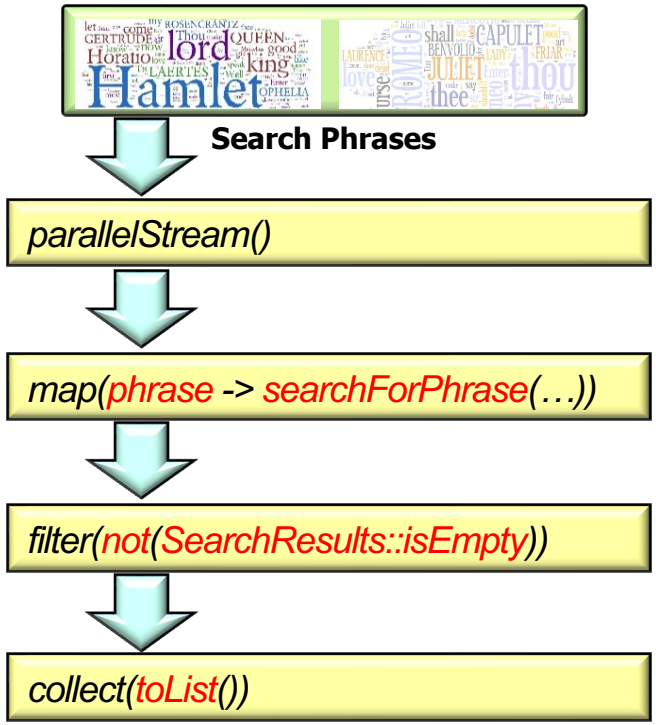
- The same aggregate operations can be used for sequential & parallel streams
  - Java streams can thus treat parallelism as an optimization & leverage all available cores!
  - Behaviors run by aggregate operations must be designed carefully to avoid accessing unsynchronized shared mutable data..


```
parallelStream()
map(phrase -> searchForPhrase(…))
filter(not(SearchResults::isEmpty))
collect(toList())
```

See henrikeichenhardt.blogspot.com/2013/06/why-shared-mutable-state-is-root-of-all.html

Transitioning from Sequential Streams to Parallel Streams

- The same aggregate operations can be used for sequential & parallel streams
  - Java streams can thus treat parallelism as an optimization & leverage all available cores!
  - Behaviors run by aggregate operations must be designed carefully to avoid accessing unsynchronized shared mutable data..
    - An easy way to avoid shared mutable data is to use stateless behaviors



See en.wikipedia.org/wiki/Side_effect_(computer_science)

End of An Overview of Parallelism & Java Parallel Streams