An Overview of Parallelism & Java Parallel Streams

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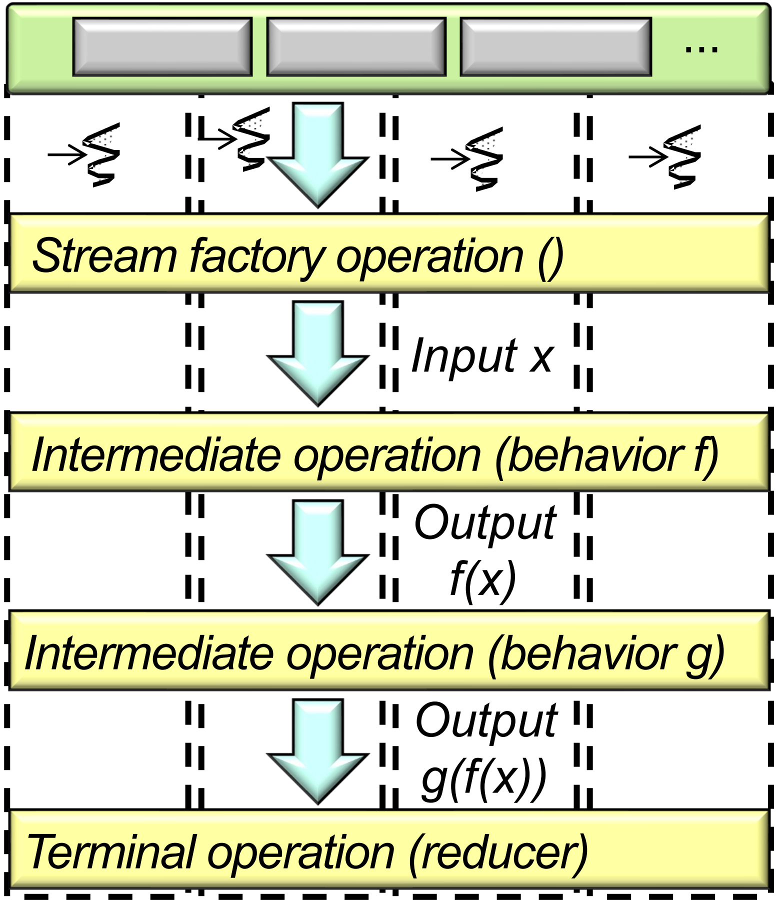
Learning Objectives in this Part of the Lesson

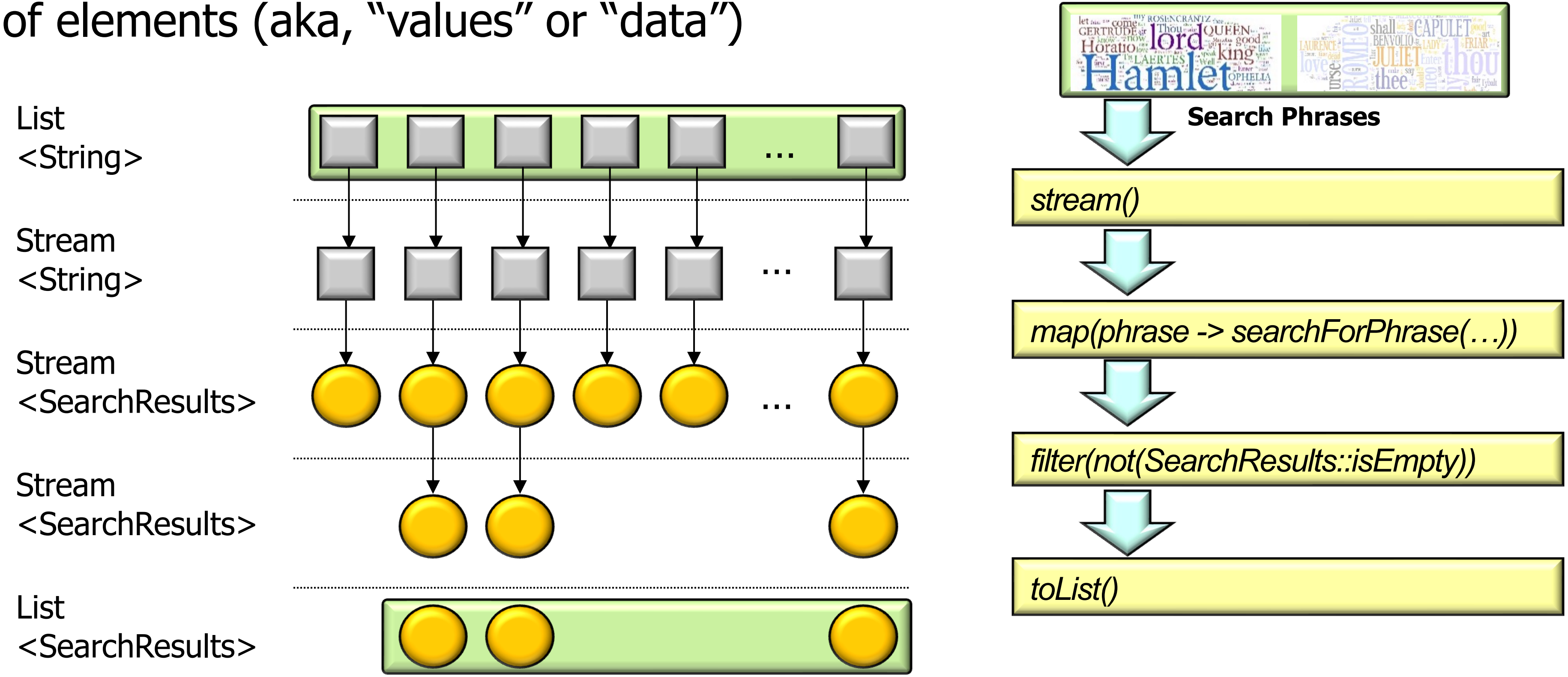
- Know how aggregate operations & functional programming features are applied seamlessly in parallel streams


...
Stream factory operation ()
Input x
Intermediate operation (behavior f)
Output f(x)
Intermediate operation (behavior g)
Output g(f(x))
Terminal operation (reducer)

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”)



List <String>

Stream <String>

Stream <SearchResults>

Stream <SearchResults>

List <SearchResults>

Search Phrases

stream()

map(phrase -> searchForPhrase(…))

filter(not(SearchResults::isEmpty))

toList()

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

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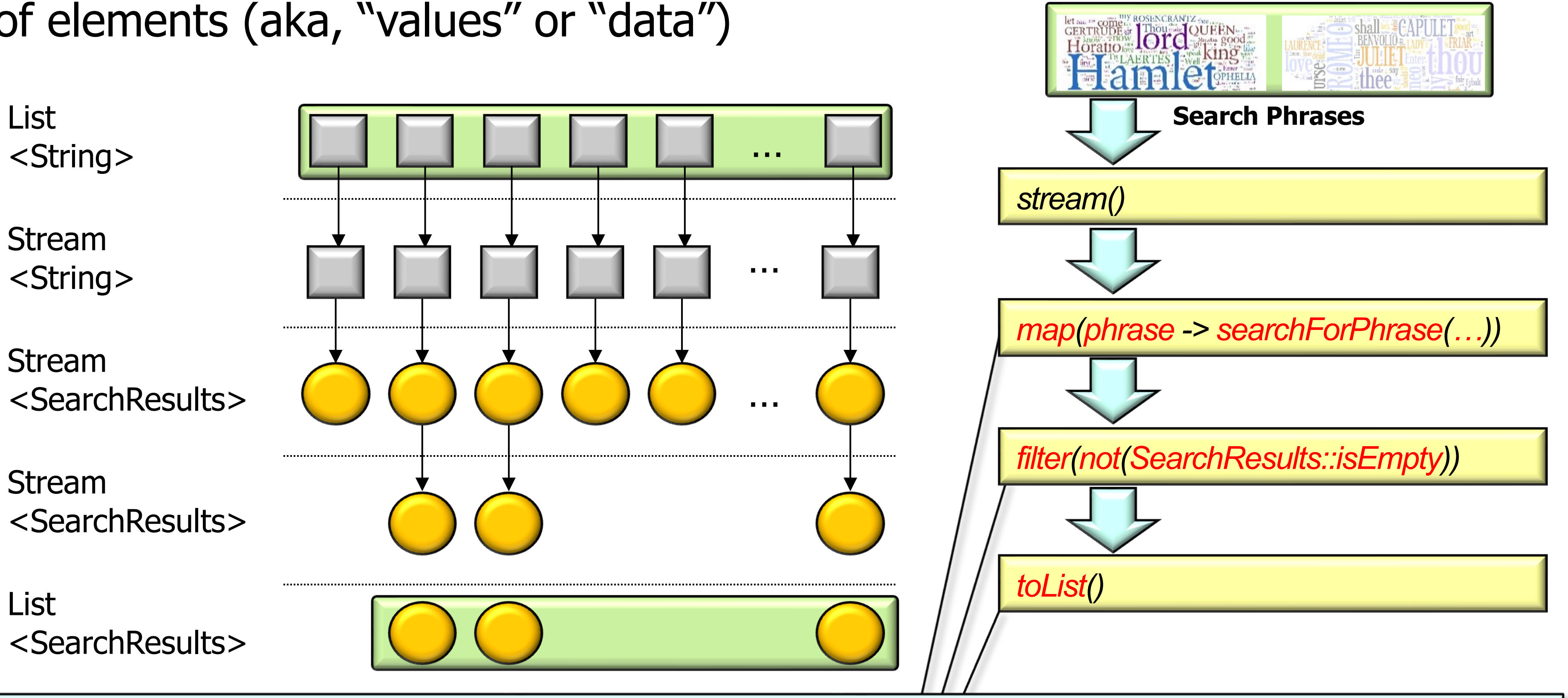

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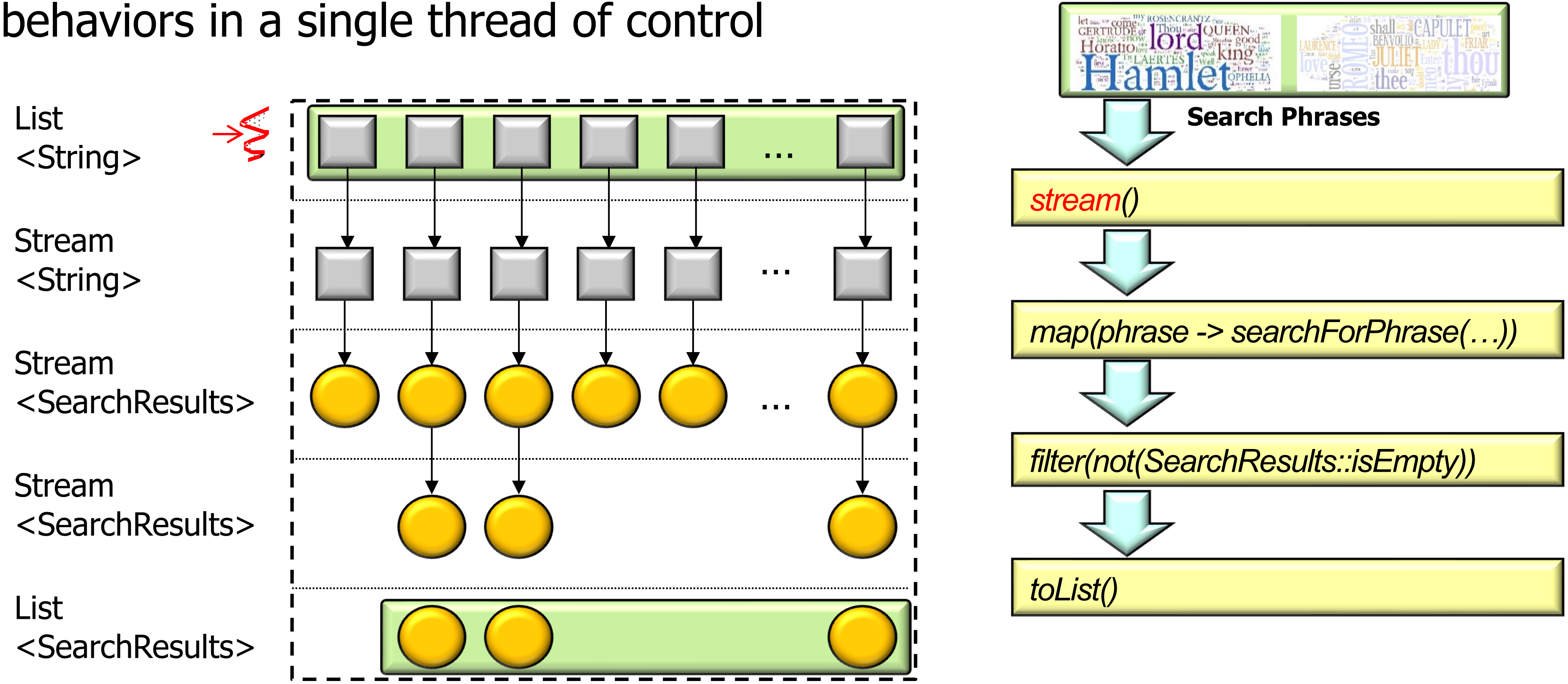
Aggregate operations use internal iteration & behaviors to process elements in a stream

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



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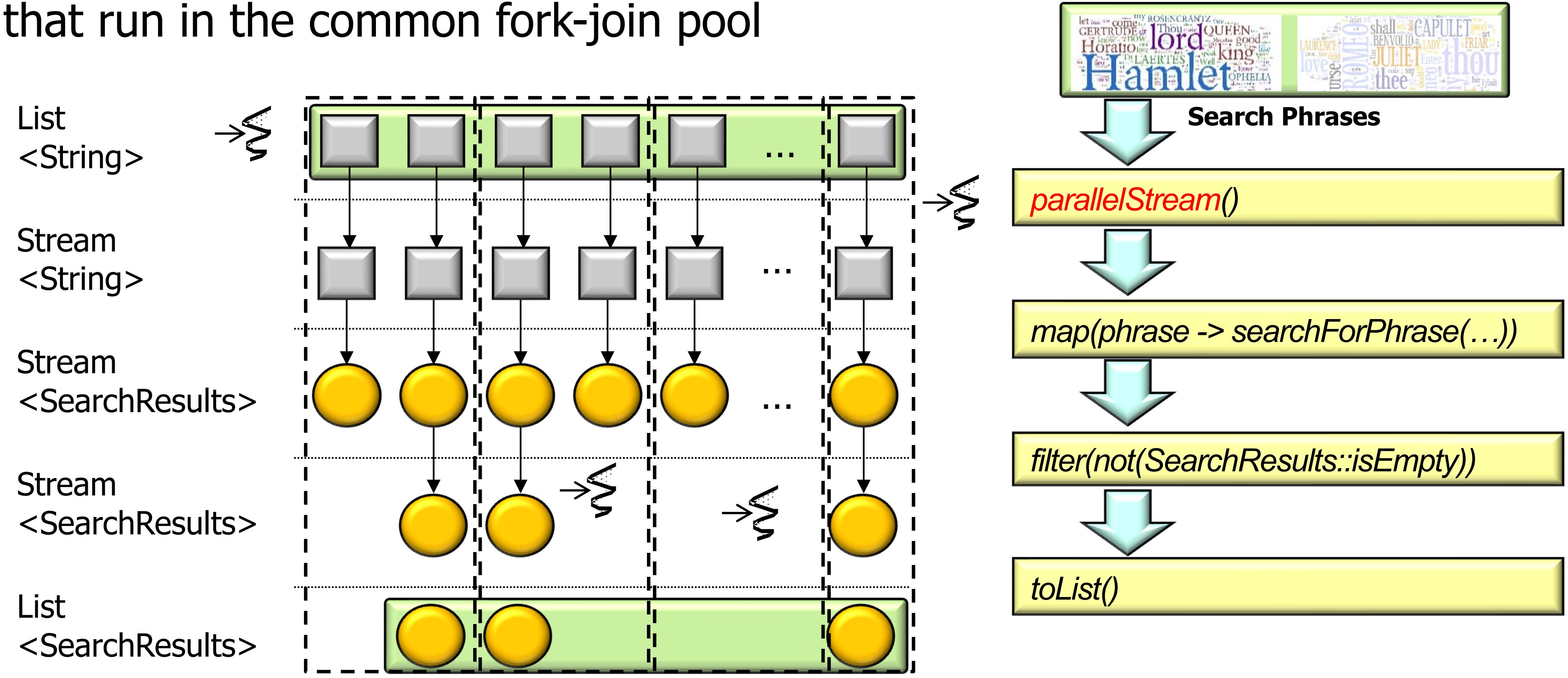
Transitioning from Sequential Streams to Parallel Streams

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



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

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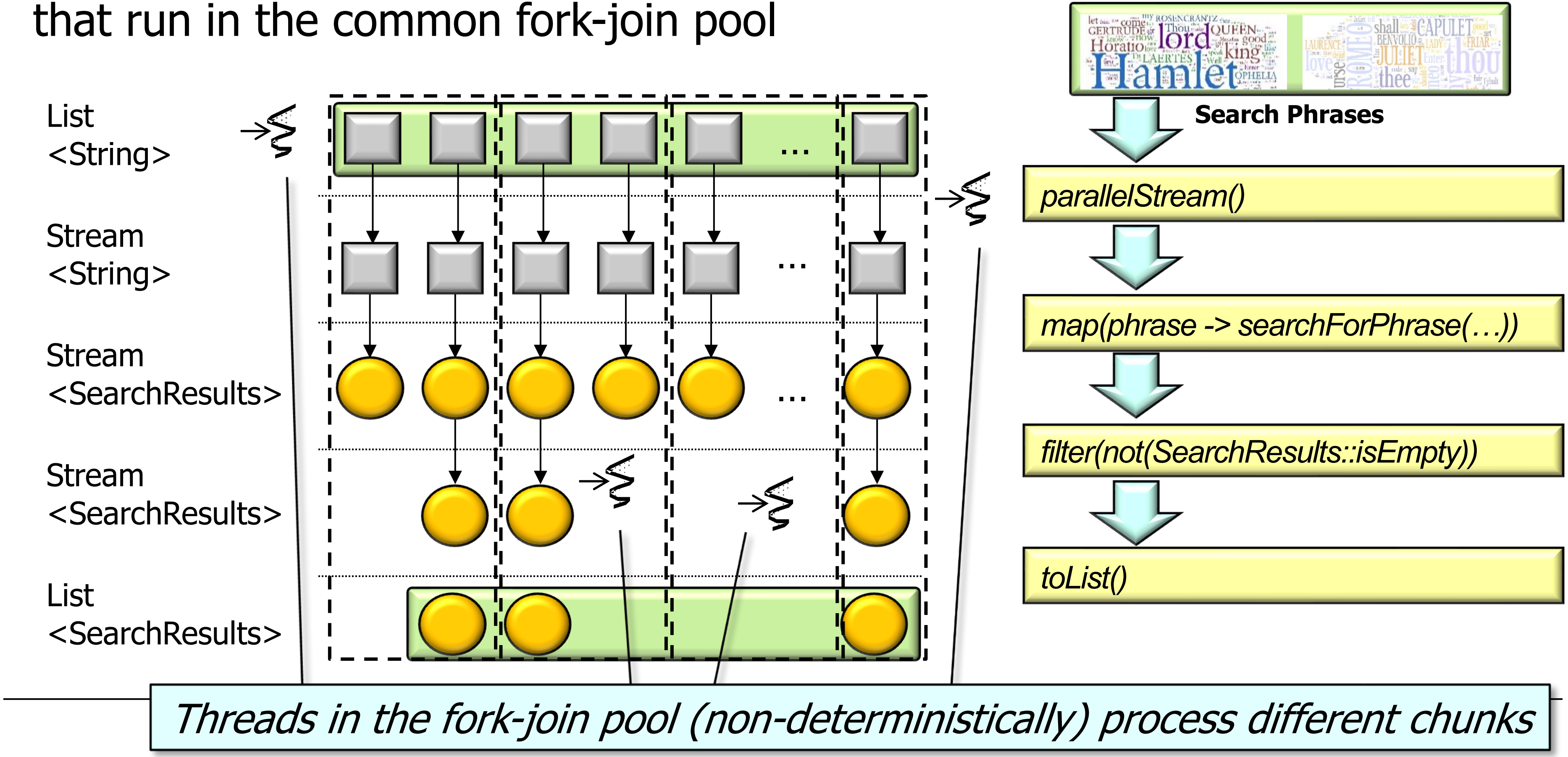
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…
Threads in the fork-join pool (non-deterministically) process different chunks

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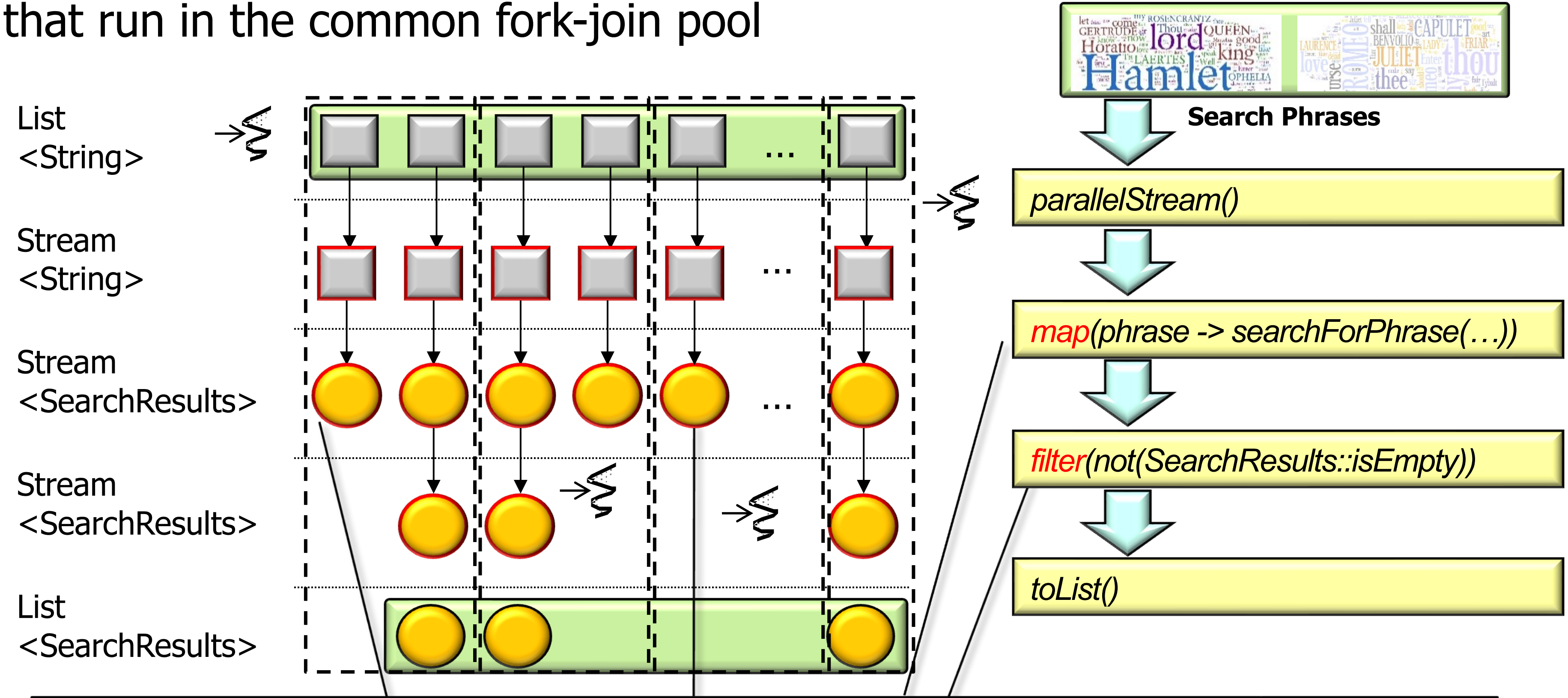

Intermediate operations cleverly process behaviors on these chunks in parallel

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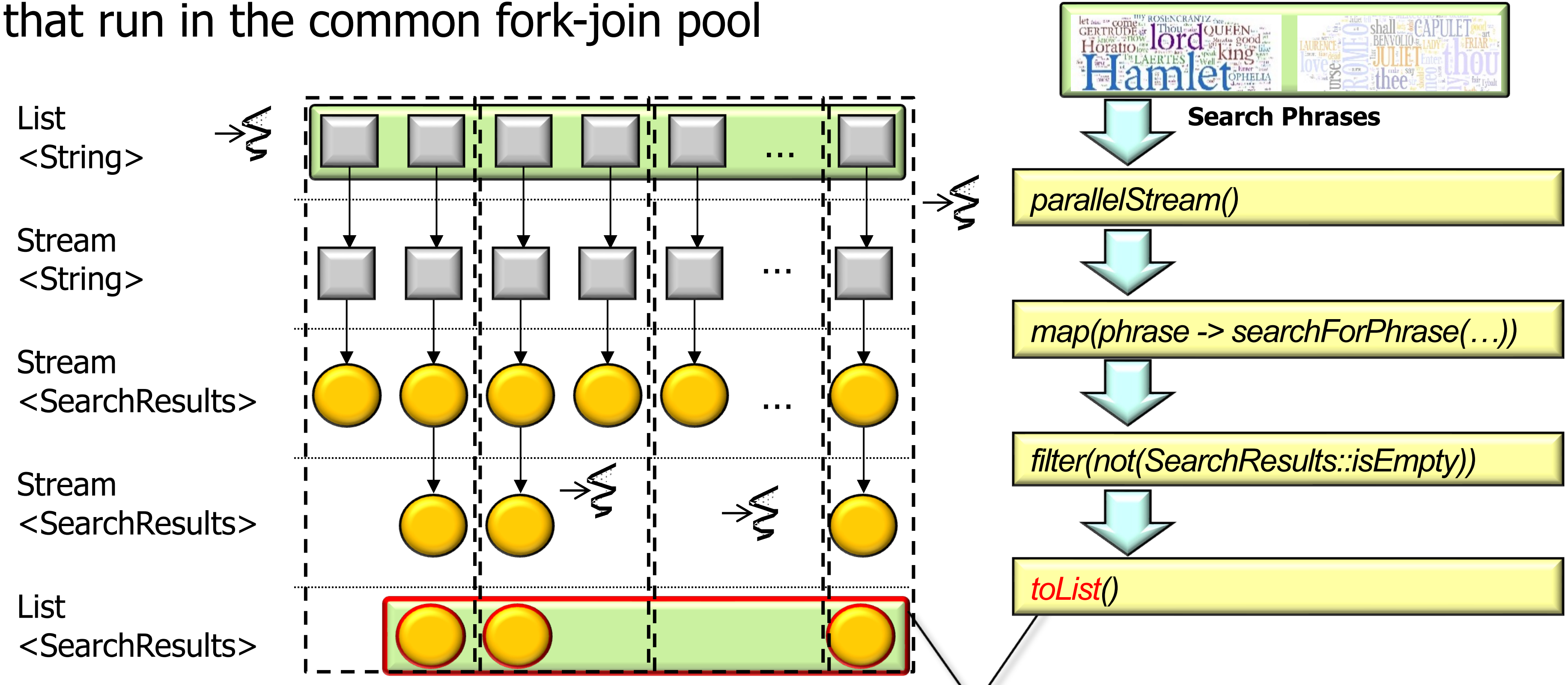

A terminal operation triggers processing & combines the chunks into a single result

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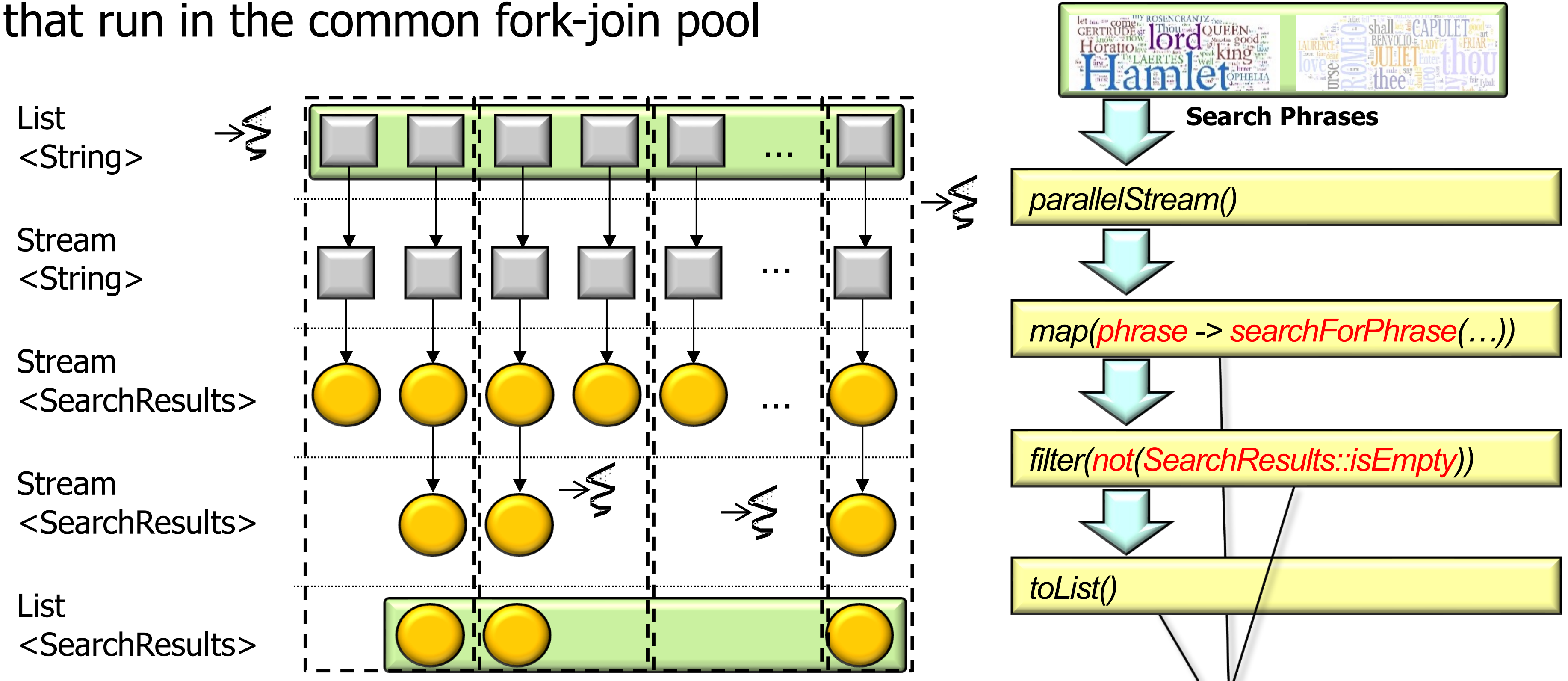

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(Stateless) Java lambda expressions & method references are used to pass behaviors

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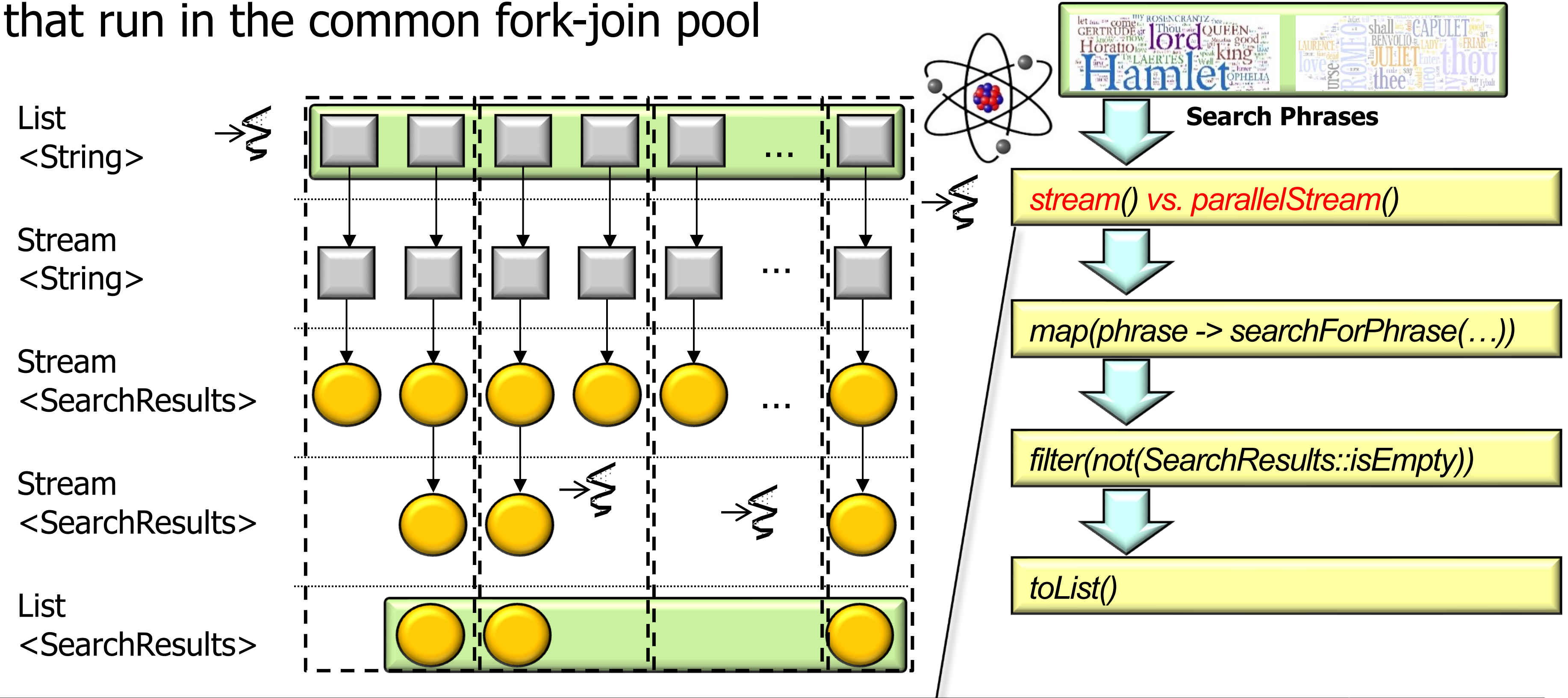

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stream() vs. parallelStream()

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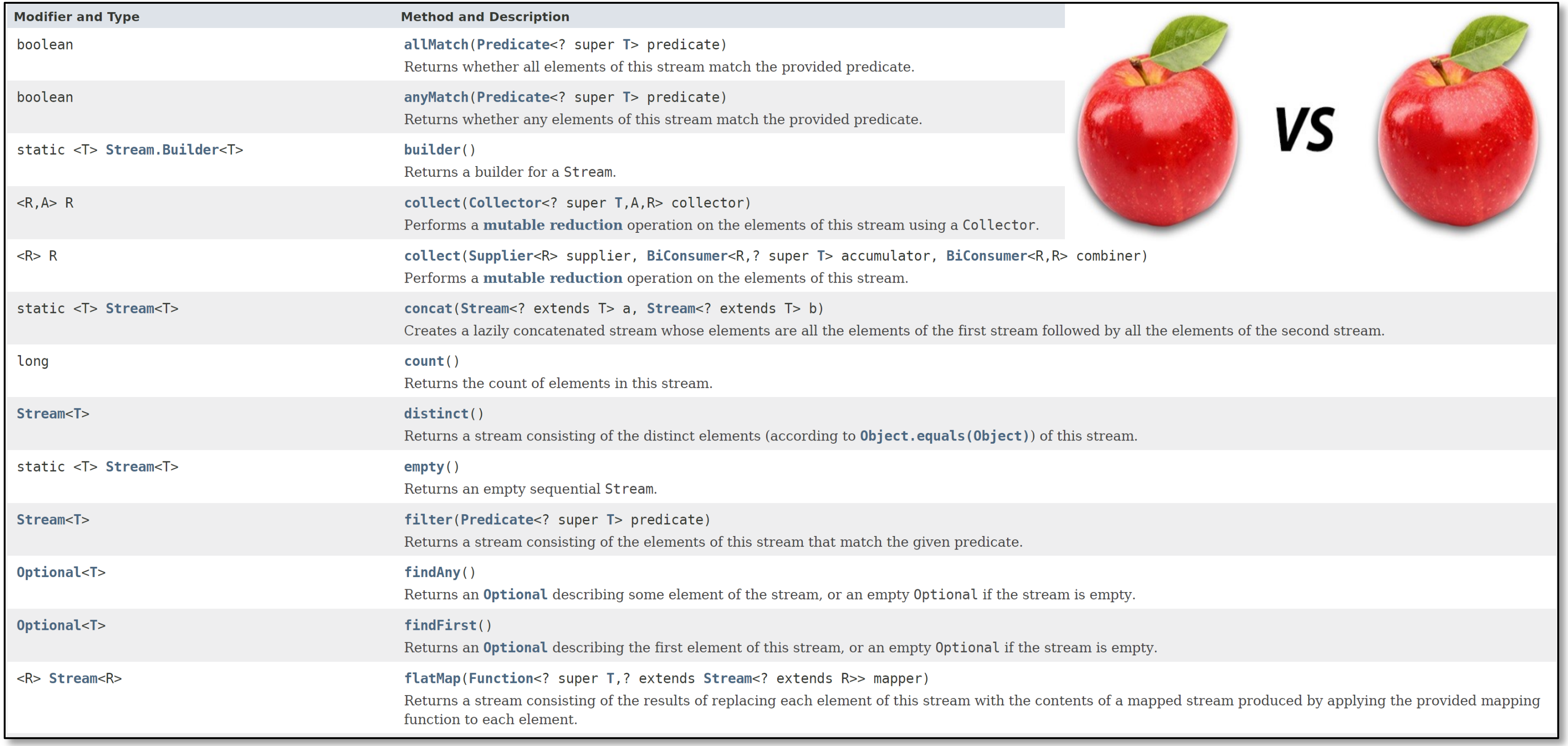
Ideally, minuscule changes are needed to transition from sequential to parallel stream

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

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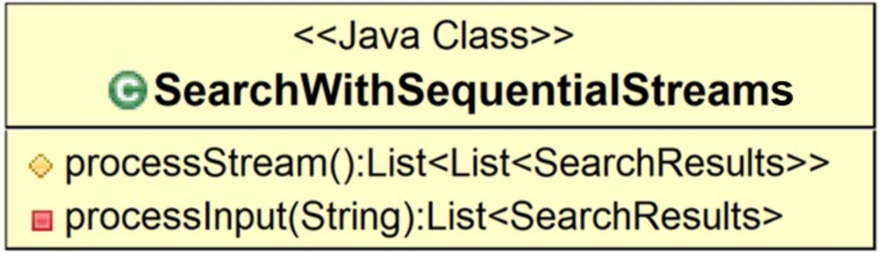
- The same aggregate operations can be used for sequential & parallel streams

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

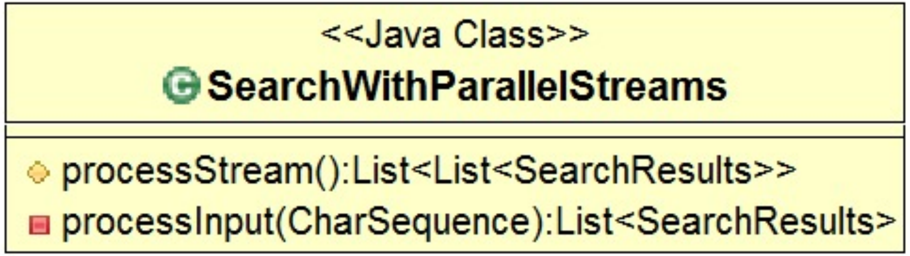


<<Java Class>>

SearchWithSequentialStreams

◇ processStream():List<List<SearchResults>>

■ processInput(String):List<SearchResults>

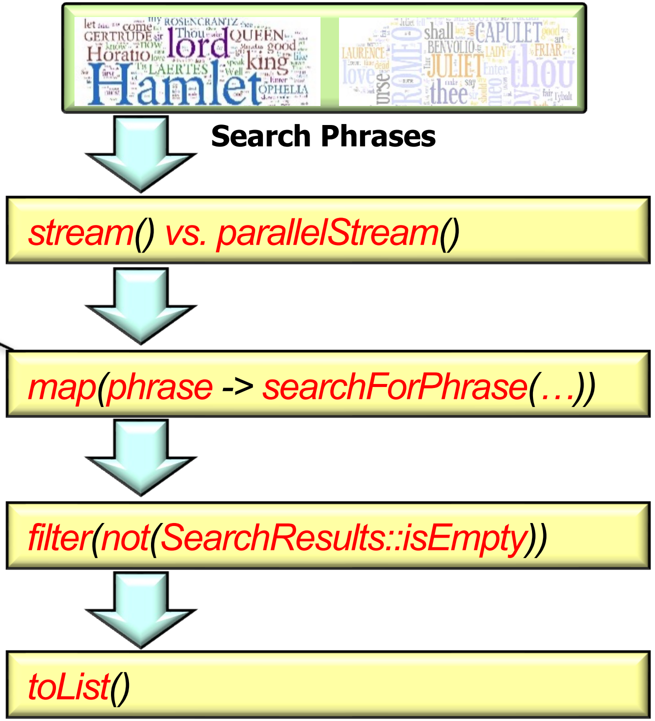


<<Java Class>>

SearchWithParallelStreams

◇ processStream():List<List<SearchResults>>

■ processInput(CharSequence):List<SearchResults>



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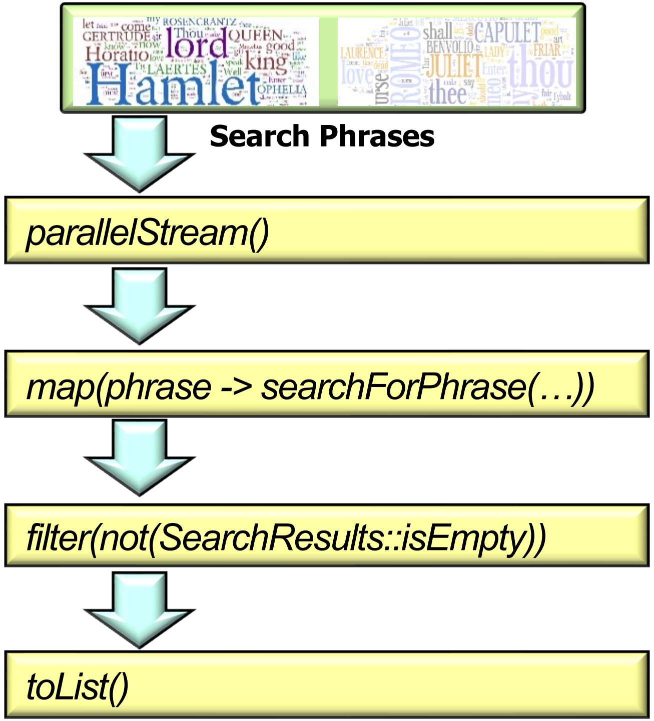
  - Java streams can thus treat parallelism as an optimization & leverage all available cores!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See qconlondon.com/london-2017/system/files/presentation-slides/concurrenttoparallel.pdf

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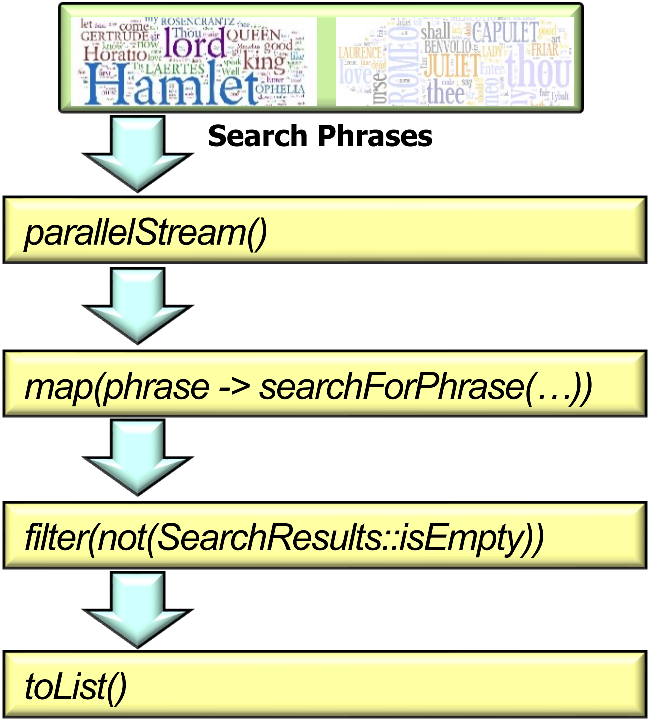
  - Behaviors run by aggregate operations must be designed carefully to avoid accessing unsynchronized shared mutable data..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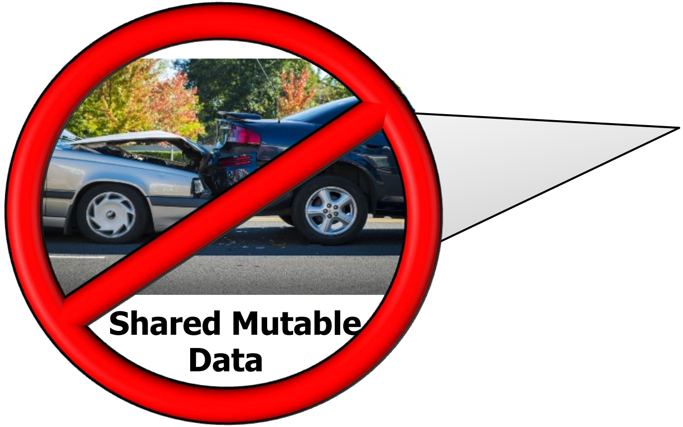

See henrikeichenhardt.blogspot.com/2013/06/why-shared-mutable-state-is-root-of-all.html

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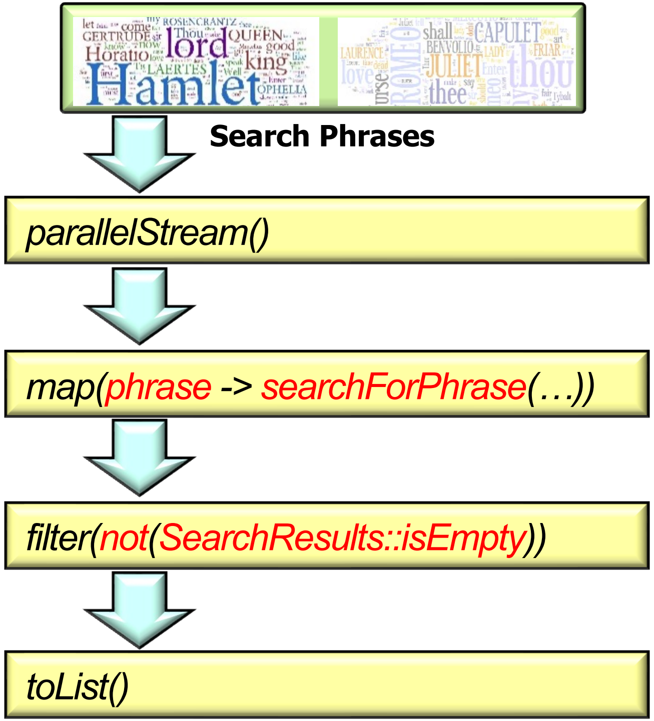
  - Java streams can thus treat parallelism as an optimization & leverage all available cores!
  - Behaviors run by aggregate operations must be designed carefully to avoid accessing unsynchronized shared mutable data..
    - An easy way to avoid shared mutable data is to use stateless behaviors



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

End of An Overview of Parallelism & Java Parallel Streams