# Java 8 Parallel Streams Internals

# (Part 1)

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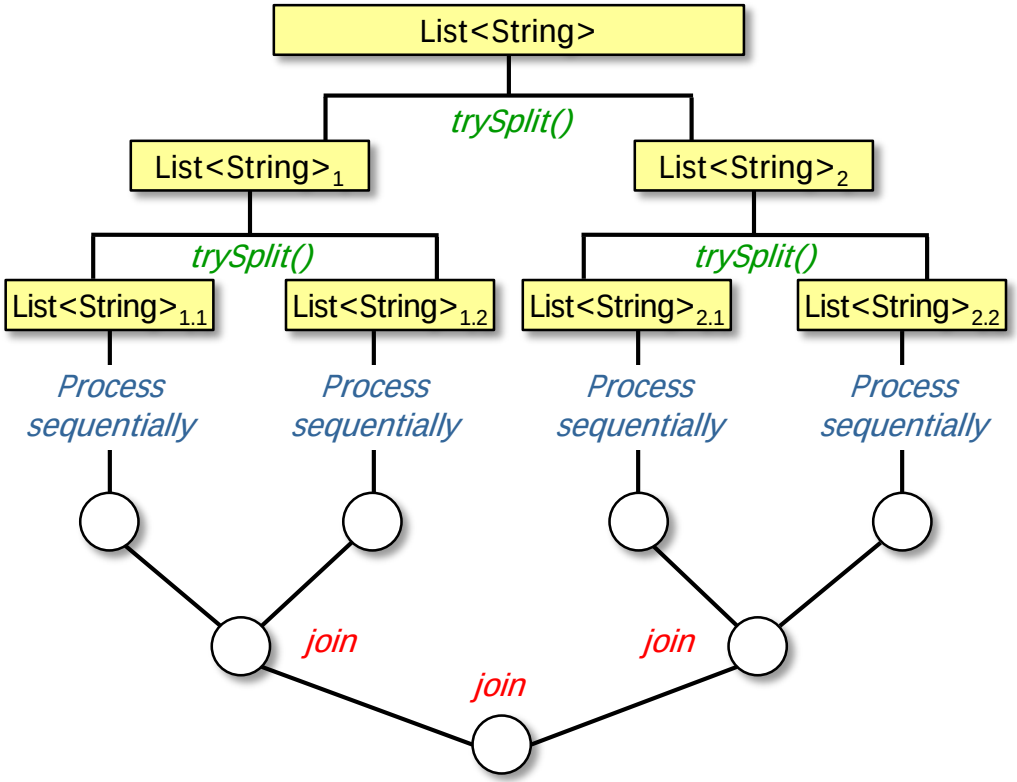
# Learning Objectives in this Part of the Lesson

- Understand parallel stream internals




See www.ibm.com/developerworks/library/j-java-streams-3-brian-goetz

# Learning Objectives in this Part of the Lesson

- Understand parallel stream internals, e.g.
  - Know what can change & what can't

# Why Knowledge of Parallel Streams Matters

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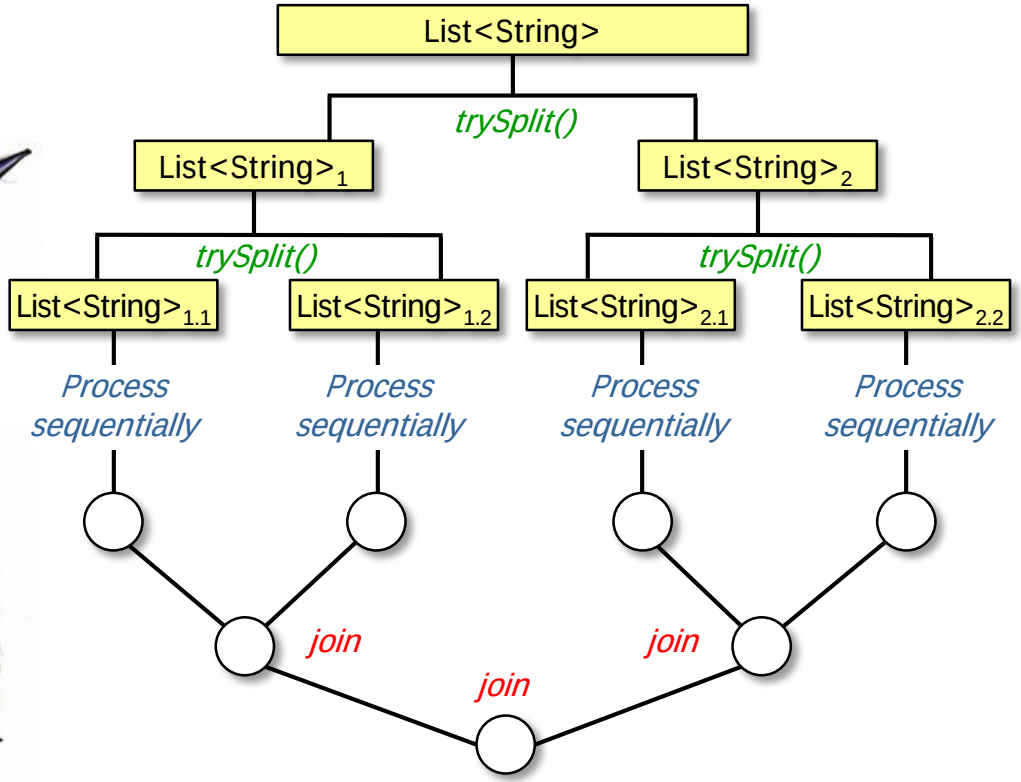
- Knowledge of (parallel) streams internals will make you a better Java 8 streams programmer!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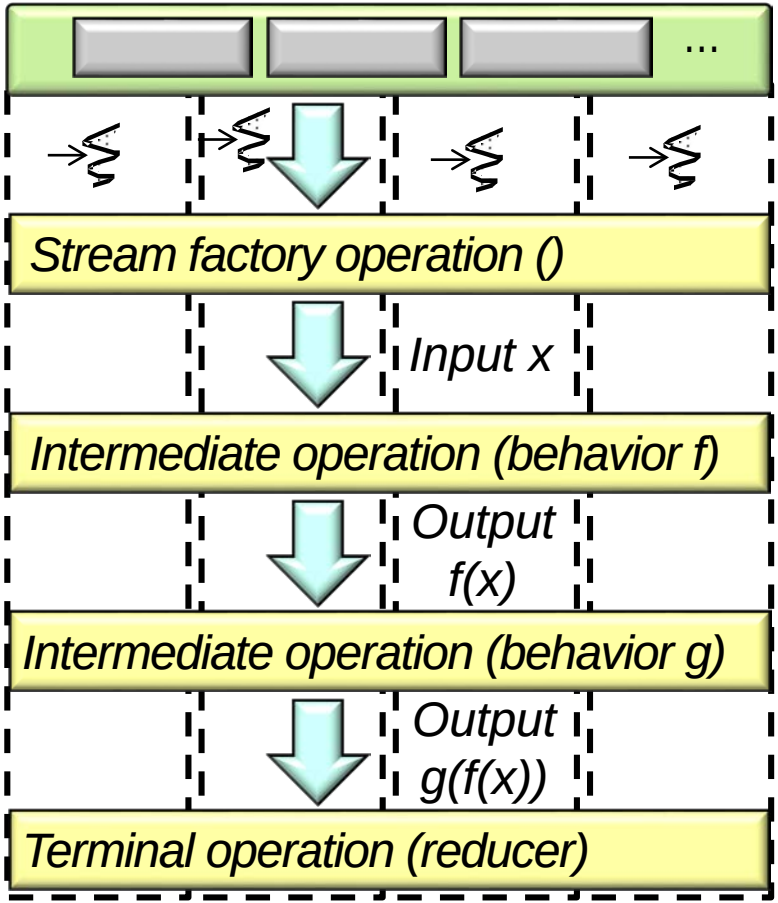
# Why Knowledge of Parallel Streams Matters

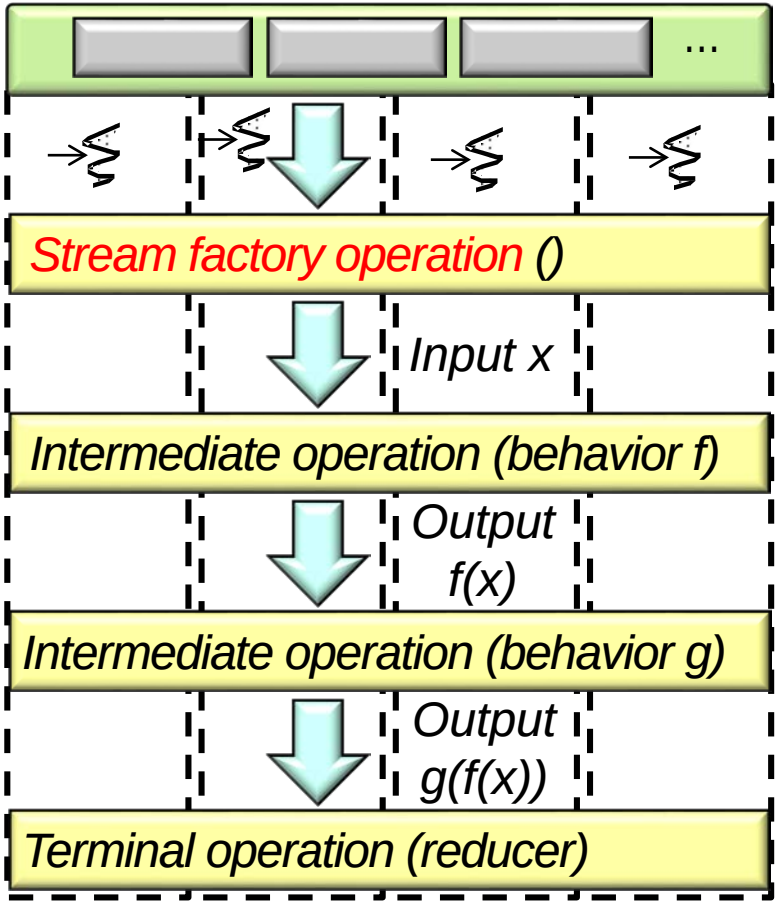
- Recall the 3 phases of a Java 8 parallel stream




See docs.oracle.com/javase/tutorial/collections/streams/parallelism.html

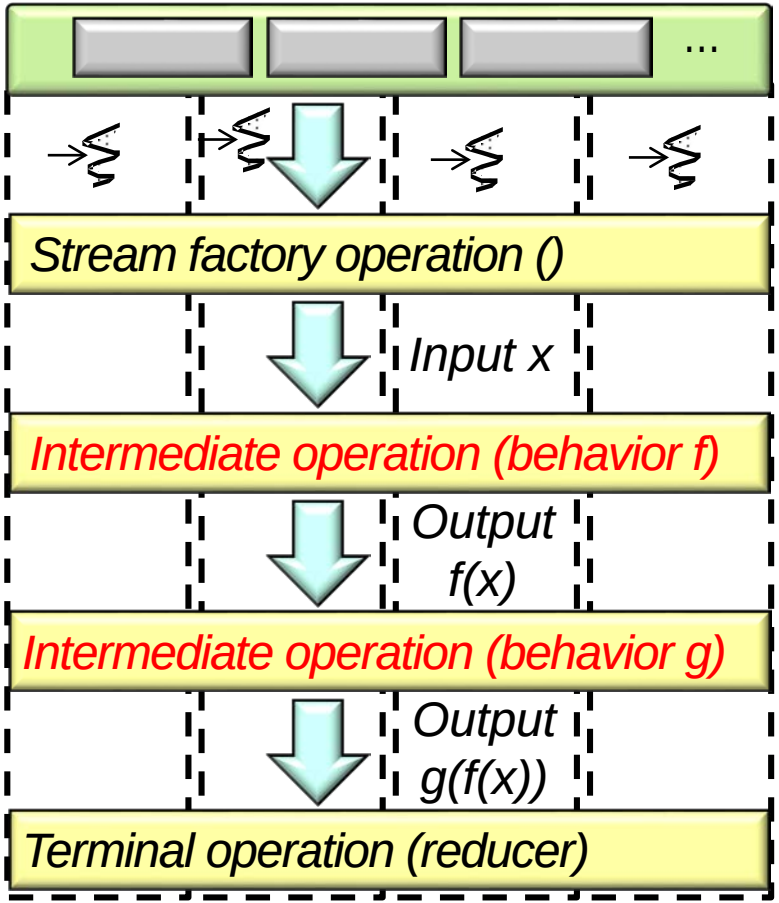
# Why Knowledge of Parallel Streams Matters

- Recall the 3 phases of a Java 8 parallel stream
  - *Splits* its elements into multiple chunks



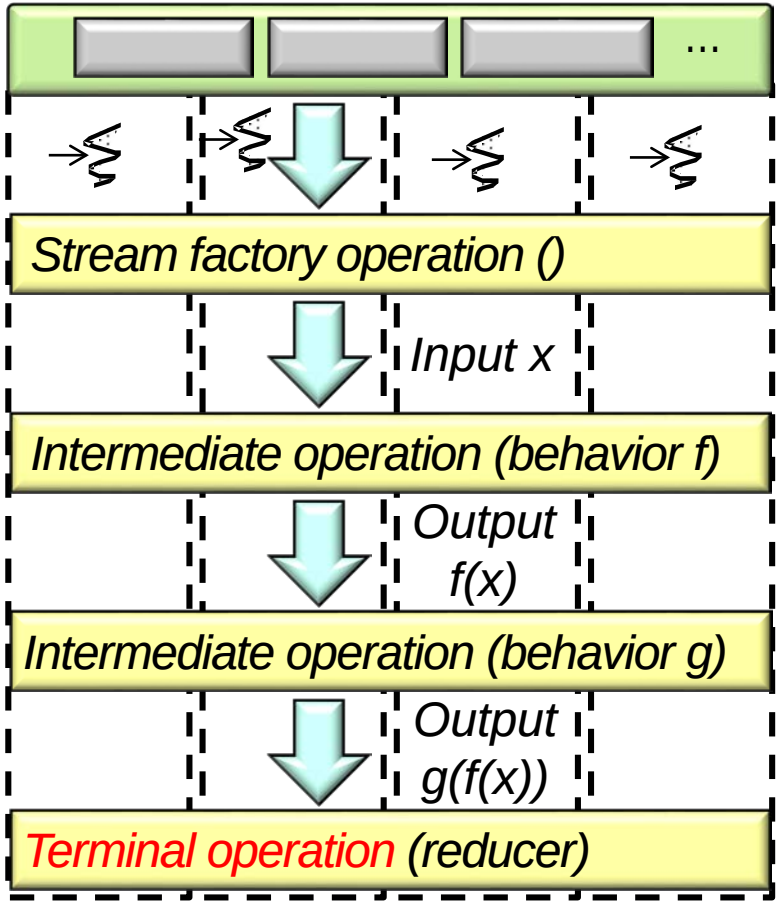
# Why Knowledge of Parallel Streams Matters

- Recall the 3 phases of a Java 8 parallel stream
  - *Splits* its elements into multiple chunks
  - *Applies* processing on these chunks to run them in a thread pool independently



# Why Knowledge of Parallel Streams Matters

- Recall the 3 phases of a Java 8 parallel stream
  - *Splits* its elements into multiple chunks
  - *Applies* processing on these chunks to run them in a thread pool independently
  - *Combines* partial results into a single result



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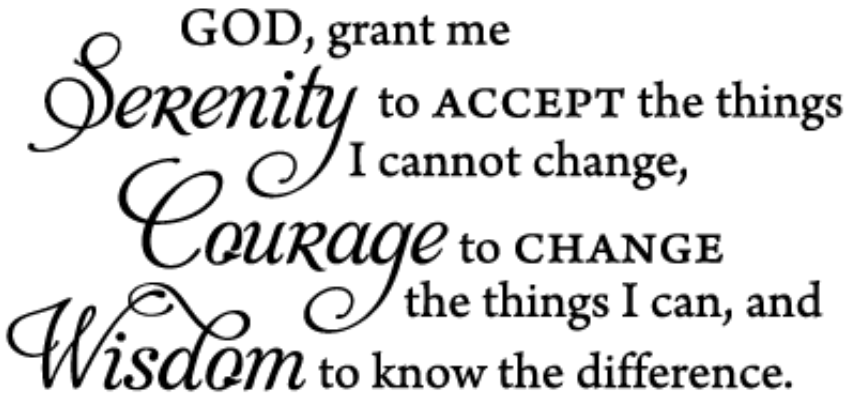


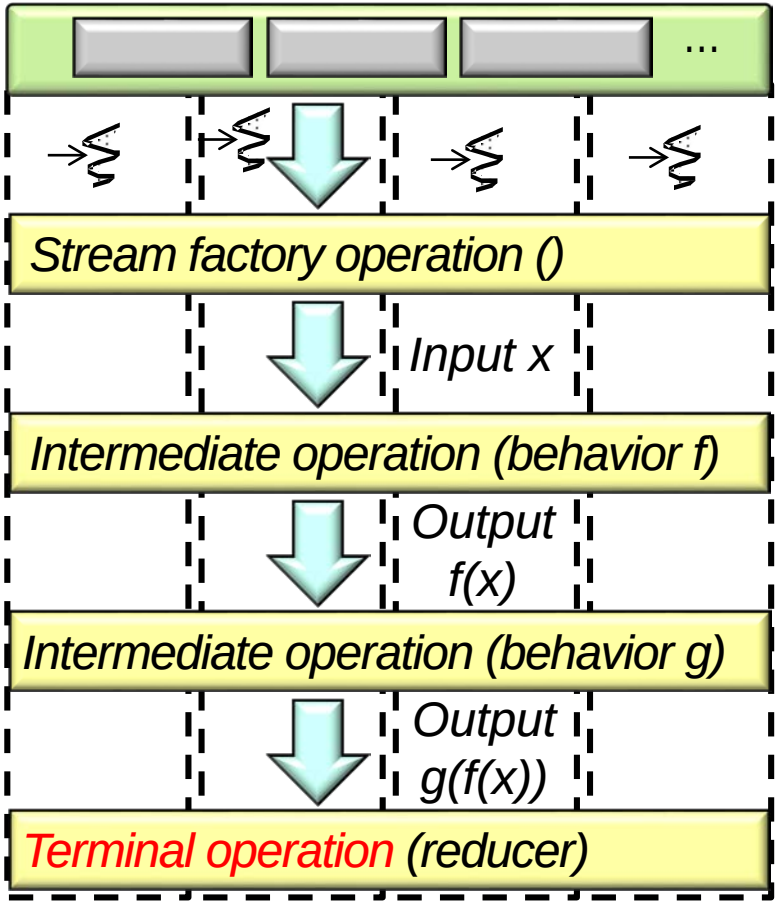


It's important to which of these phases you can control & which you can't!

# Parallel Stream Splitting & Thread Pool Mechanisms

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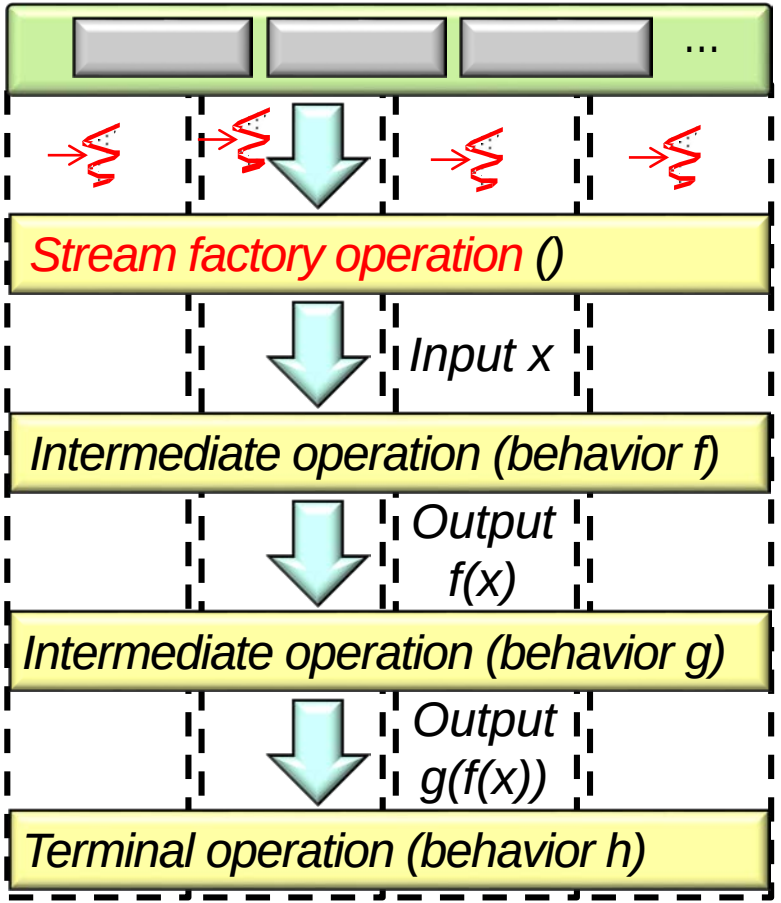
- A parallel stream's splitting & thread pool mechanisms are often invisible



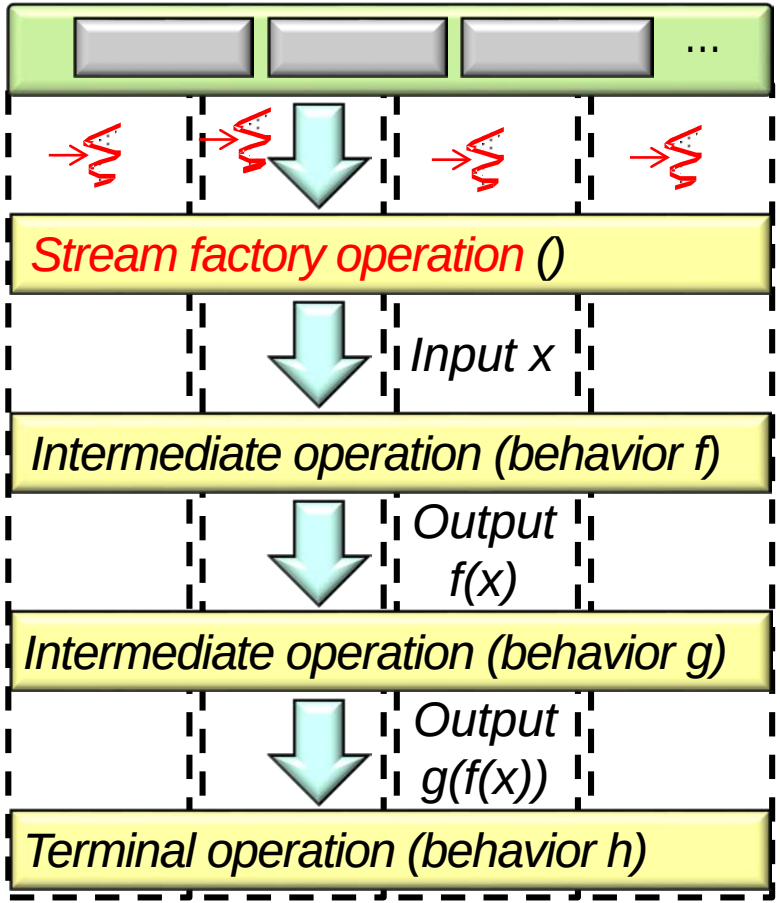
# Parallel Stream Splitting & Thread Pool Mechanisms

- A parallel stream's splitting & thread pool mechanisms are often invisible, e.g.
  - Java collections have predefined spliterators

```
public interface Collection<E> {

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

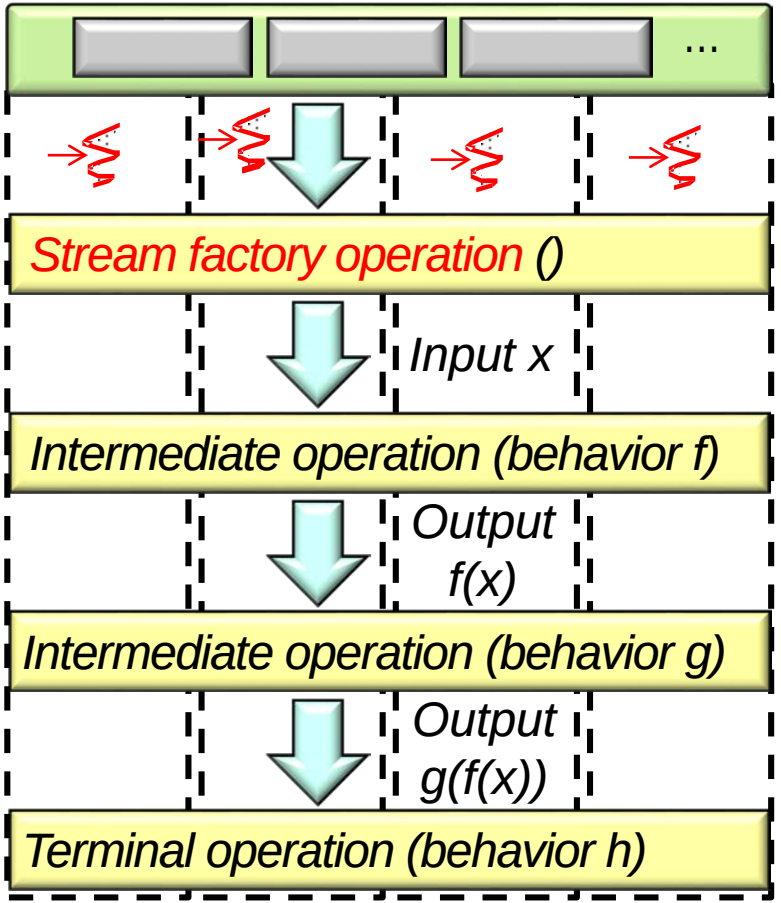
  default Spliterator<E> spliterator() {
    return Spliterators
      .spliterator(this, 0);
  }
}
```




See blog.logentries.com/2015/10/java-8-introduction-to-parallelism-and-spliterator

# Parallel Stream Splitting & Thread Pool Mechanisms

- A parallel stream's splitting & thread pool mechanisms are often invisible, e.g.
  - Java collections have predefined spliterators
  - A common fork-join pool is used by default


See www.baeldung.com/java-fork-join

# Parallel Stream Splitting & Thread Pool Mechanisms

- However, programmers can customize the behavior of splitting & thread pools

```
public interface Spliterator<T> {
  boolean tryAdvance
    (Consumer<? Super T> action);

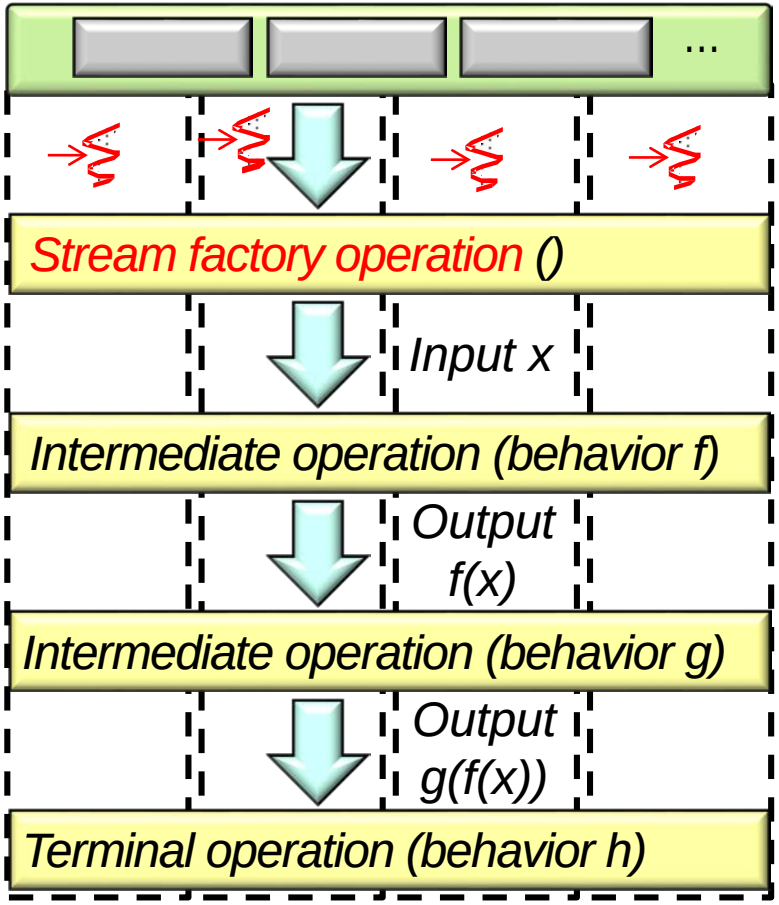
  Spliterator<T> trySplit();

  long estimateSize();

  int characteristics();
}
```

```
public interface ManagedBlocker {
  boolean block()
    throws InterruptedException;

  boolean isReleasable();
}
```




See Parts 2 & 4 of this lesson on *"Java 8 Parallel Stream Internals"*

# Parallel Stream Ordering

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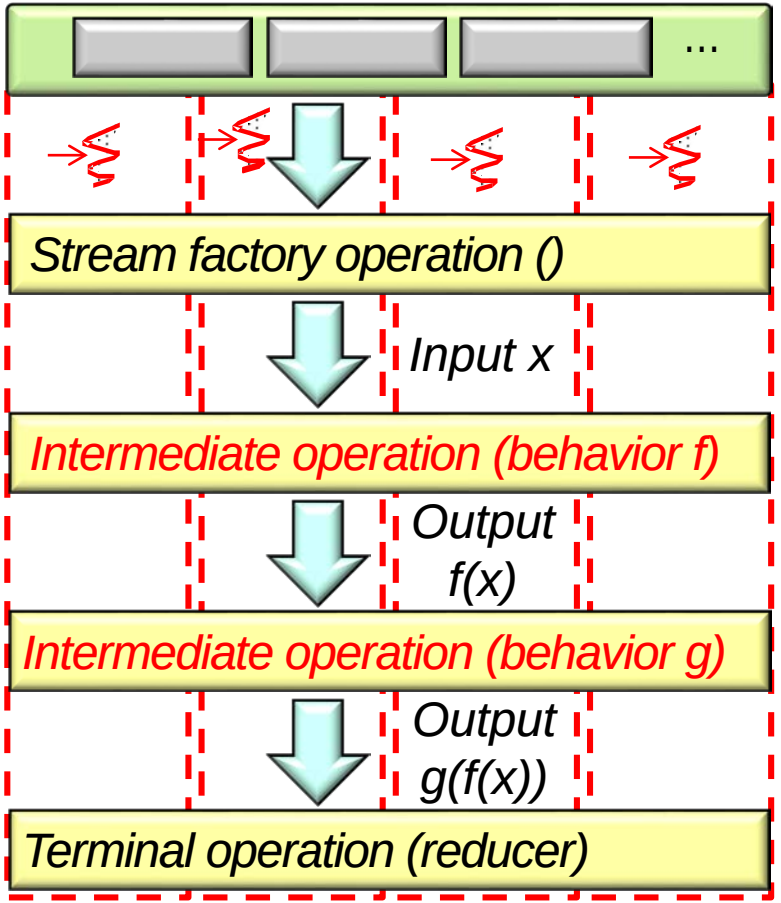
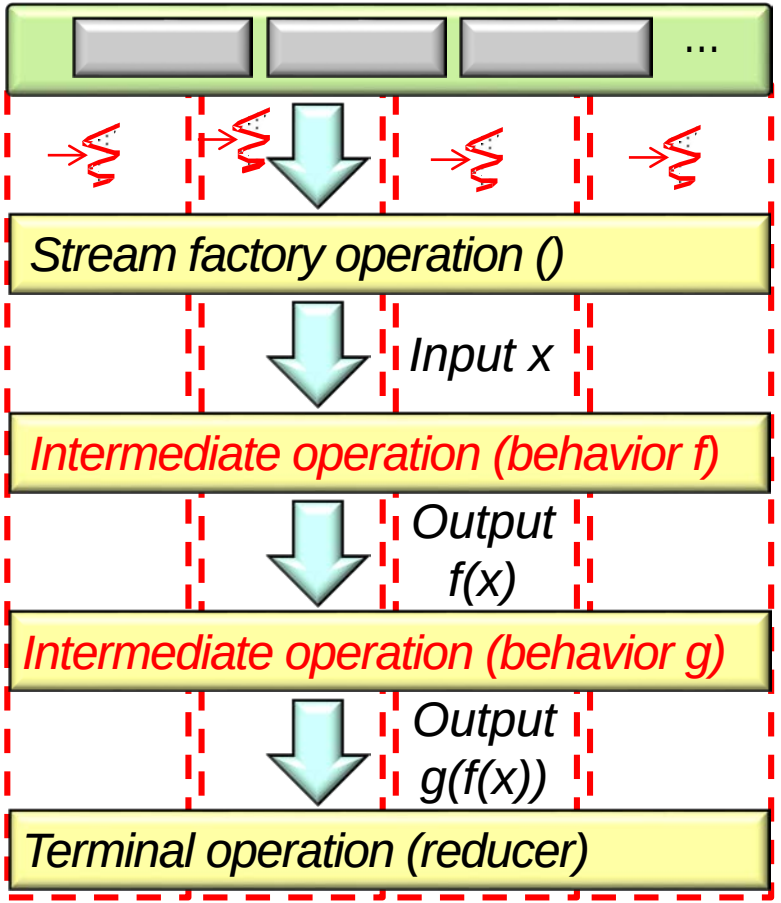
- The *order* in which chunks are processed is non-deterministic



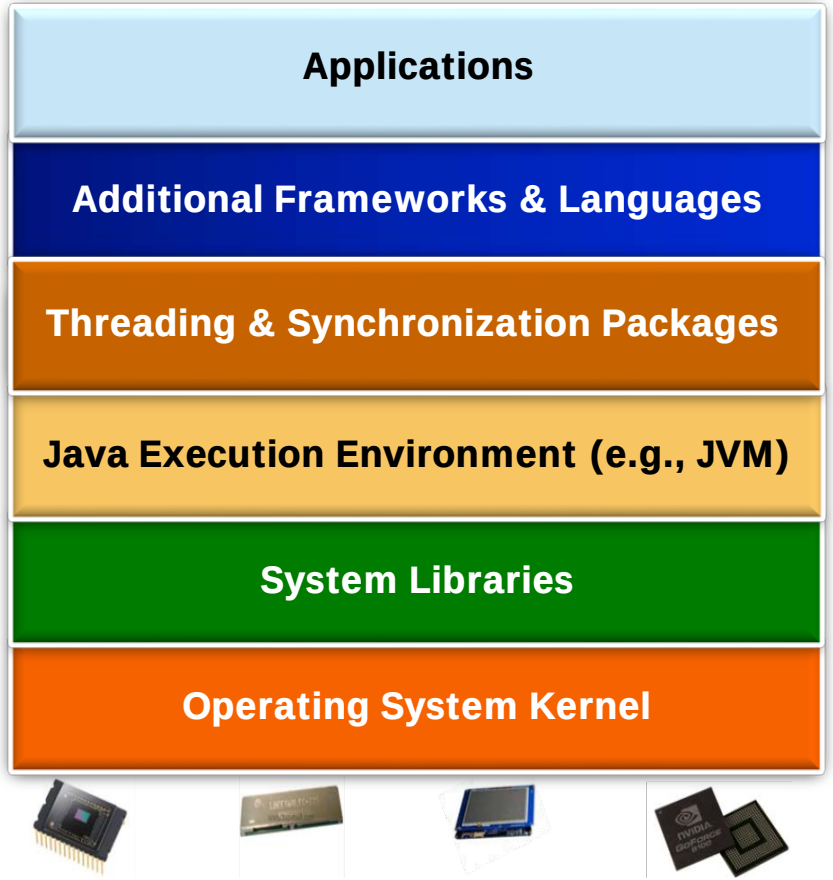
# Parallel Stream Ordering

- The *order* in which chunks are processed is non-deterministic
  - Programmers have little/no control over how chunks are processed

# Parallel Stream Ordering

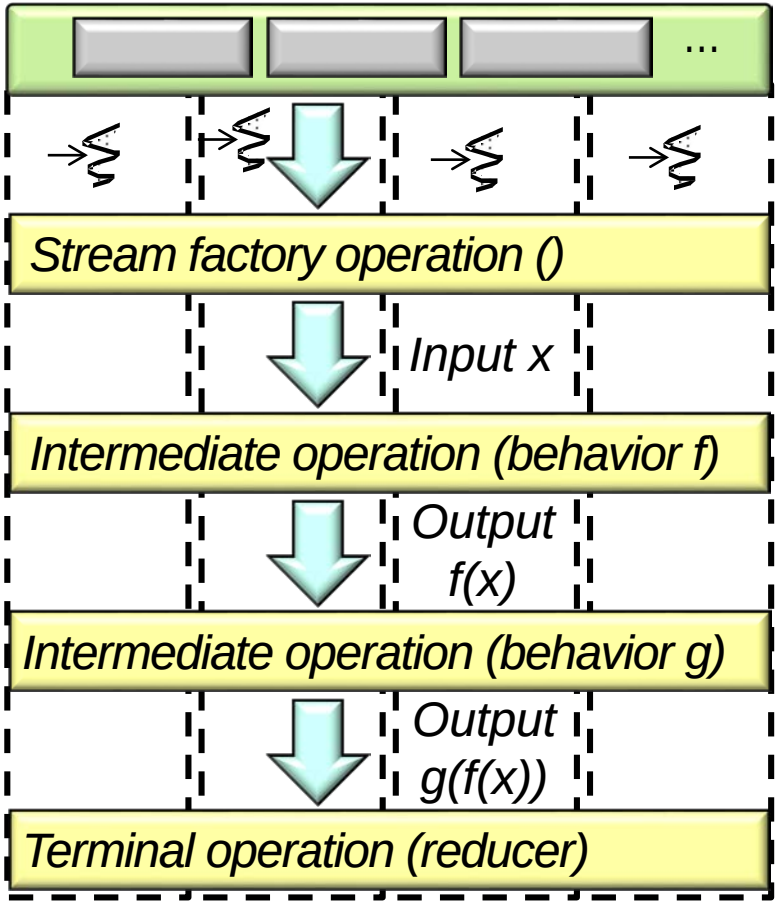
- The *order* in which chunks are processed is non-deterministic
  - Programmers have little/no control over how chunks are processed
  - Non-determinism is useful since it enables optimizations at multiple layers!


e.g., scheduling & execution of tasks via fork-join pool, JVM, hardware cores, etc.

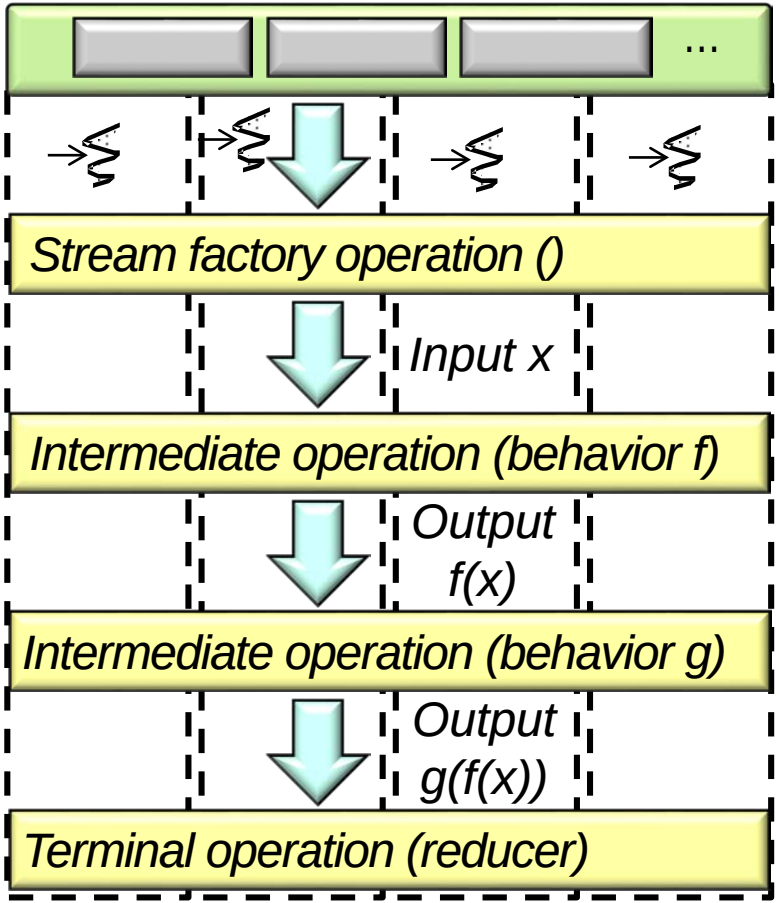
# Parallel Stream Ordering

- The *results* of the processing are more deterministic

# Parallel Stream Ordering

- The *results* of the processing are more deterministic
  - Programmers can control how results are presented

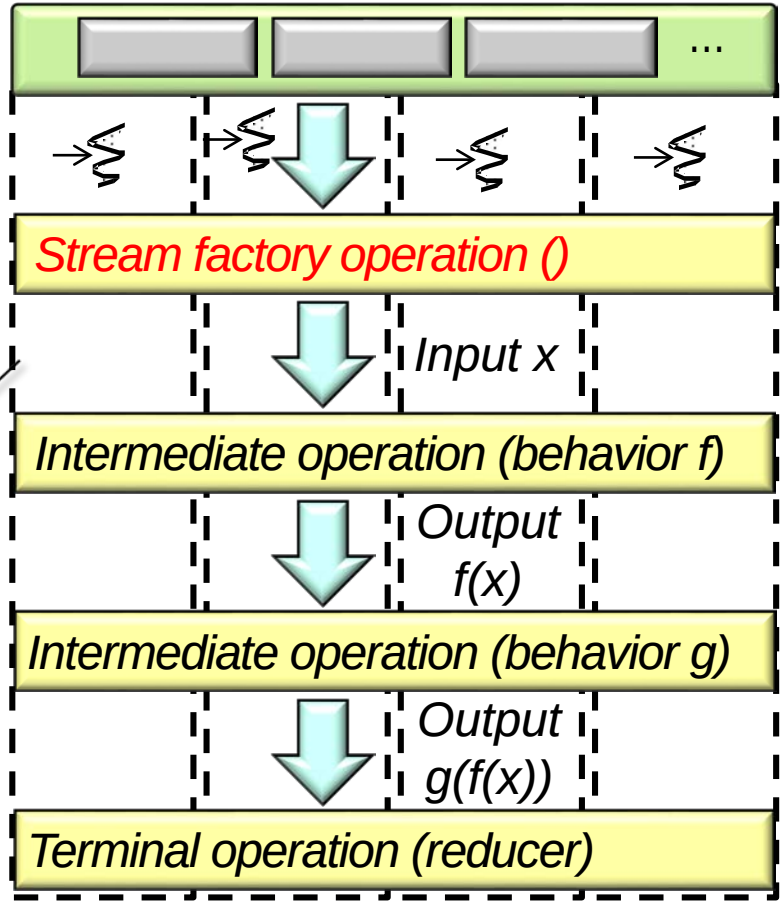



See www.logicbig.com/tutorials/core-java-tutorial/java-util-stream/ordering

# Parallel Stream Ordering

- The *results* of the processing are more deterministic
  - Programmers can control how results are presented
    - Order is maintained if the source is ordered & the aggregate operations used are obliged to maintain order

*It doesn't matter whether the stream is parallel or sequential*

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# Parallel Stream Ordering

- The *results* of the processing are more deterministic
  - Programmers can control how results are presented
    - Order is maintained if the source is ordered & the aggregate operations used are obliged to maintain order
      - Ordered spliterators, ordered collections, & static stream factory methods respect “encounter order”

```
List<Integer> list =
  Arrays.asList(1, 2, ...);
```

*The encounter order is [1, 2, 3, 4, ...] since list is ordered*

```
Integer[] doubledList = list
    .parallelStream()
    .filter(x -> x % 2 == 0)
    .map(x -> x * 2)
    .toArray(Integer[]::new);
```

See github.com/douglascraigschmidt/LiveLessons/tree/master/Java8/ex21

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*The result **must** be [2, 4, ...]*

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      - Ordered spliterators, ordered collections, & static stream factory methods respect “encounter order”
    - Unordered collections don’t need to respect “encounter order”

```
Set<Integer> set = new
  HashSet<>
    (Arrays.asList(1, 2, ...);
```

*A HashSet is unordered*

```
Integer[] doubledSet = set
   .parallelStream()
   .filter(x -> x % 2 == 0)
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```
Integer[] doubledSet = set
   .parallelStream()
   .filter(x -> x % 2 == 0)
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```

*This code runs faster since encounter order need not be maintained*

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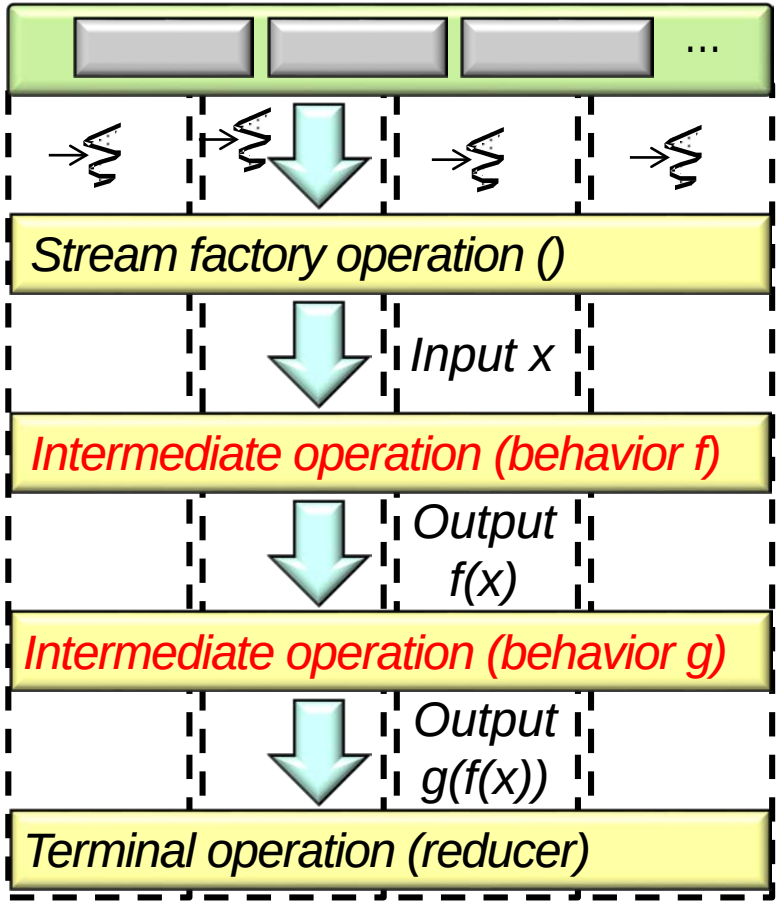
# Parallel Stream Ordering

- The *results* of the processing are more deterministic
  - Programmers can control how results are presented
    - Order is maintained if the source is ordered & the aggregate operations used are obliged to maintain order
    - Certain intermediate operations effect ordering behavior



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  - Certain intermediate operations effect ordering behavior
    - e.g., sorted(), unordered(), skip(), & limit()

```
List<Integer> list =
  Arrays.asList(1, 2, ...);

Integer[] doubledList = list
    .parallelStream()
    .distinct()
    .filter(x -> x % 2 == 0)
    .map(x -> x * 2)
    .limit(sOutputLimit)
    .toArray(Integer[]::new);
```

*The result **must** be [2, 4, ...], but the code is slow due to limit() & distinct() "stateful" semantics in parallel streams*

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```
List<Integer> list =
  Arrays.asList(1, 2, ...);

Integer[] doubledList = list
    .parallelStream()
    .unordered()
    .distinct()
    .filter(x -> x % 2 == 0)
    .map(x -> x * 2)
    .limit(sOutputLimit)
    .toArray(Integer[]::new);
```

*This code runs faster since stream is unordered & thus limit() & distinct() incur less overhead*

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- The *results* of the processing are more deterministic
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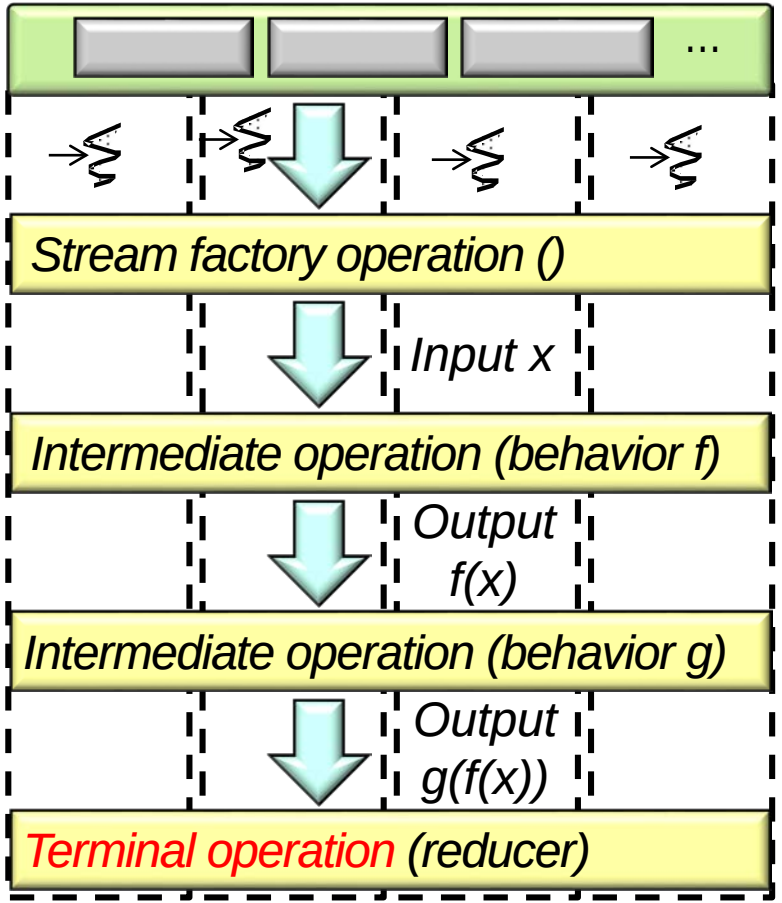

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  - Certain terminal operations also effect ordering behavior
    - e.g., forEachOrdered() & forEach()

```
List<Integer> list =
  Arrays.asList(1, 2, ...);

ConcurrentLinkedQueue
  <Integer> queue = new
    ConcurrentLinkedQueue<>();

list
  .parallelStream()
  .distinct()
  .filter(x -> x % 2 == 0)
  .map(x -> x * 2)
  .limit(sOutputLimit)
  .forEachOrdered(queue::add);
```

*Ordered*

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*Unordered*

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# End of Java 8 Parallel Stream Internals (Part 1)