Avoiding Programming Hazards with Java Parallel Streams

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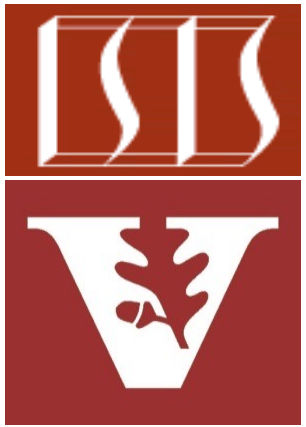

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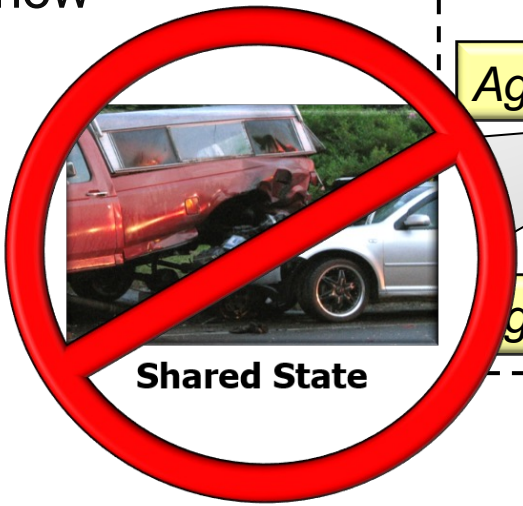
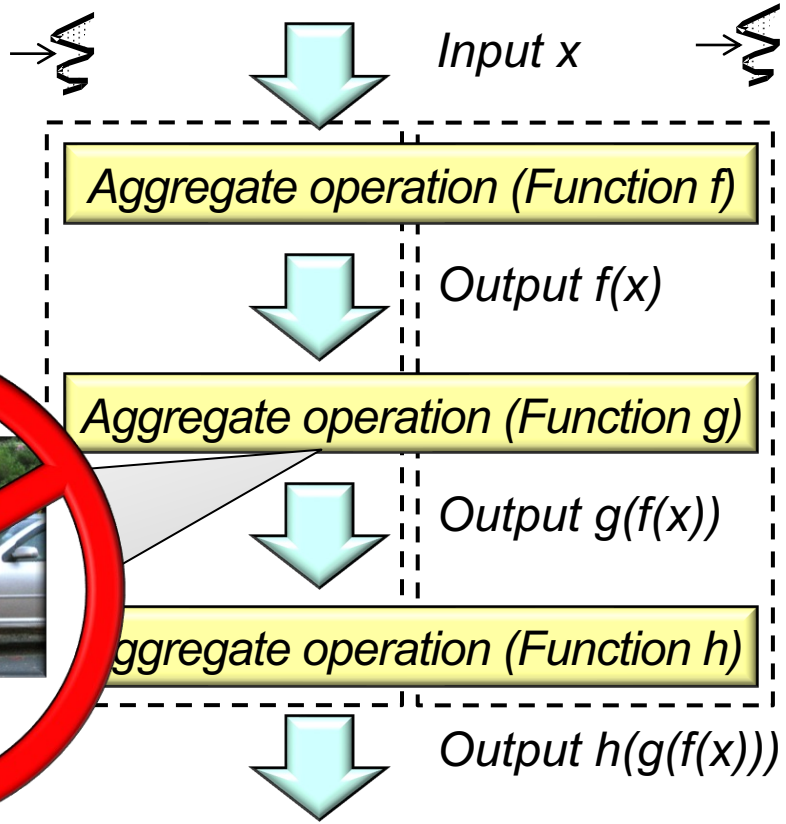
Learning Objectives in this Part of the Lesson

- Know how aggregate operations & functional programming features are applied in the parallel streams framework
- Be aware of how parallel stream phases work "under the hood"
- Recognize common programming hazards in Java parallel streams & how to avoid them





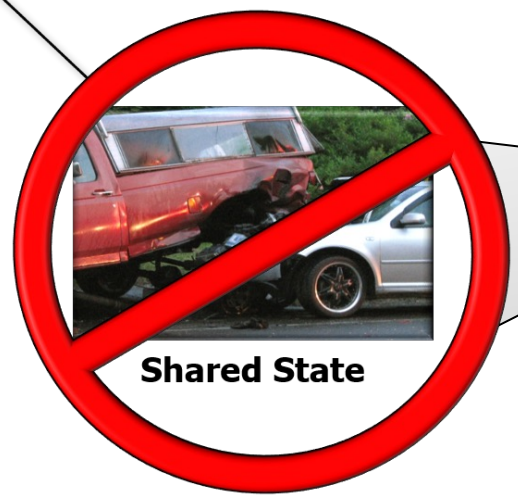
See earlier lesson on "*Java Streams: Avoiding Common Programming Mistakes*"

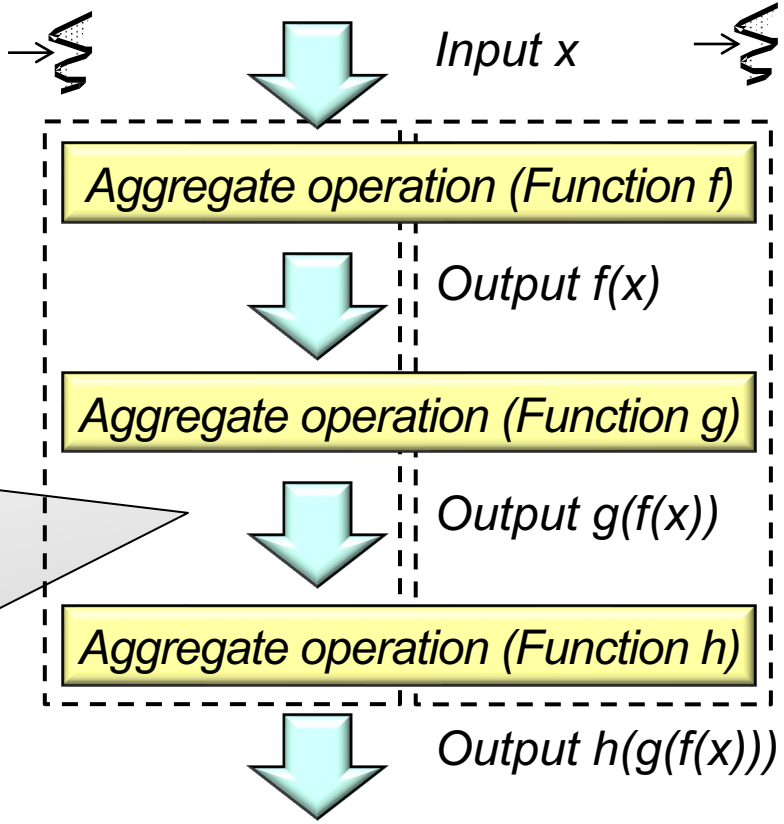
Avoiding Programming Hazards in Java Parallel Streams

Avoiding Programming Hazards in Java Parallel Streams

- The Java parallel streams framework assumes behaviors don't incur race conditions

Race conditions arise when an app depends on the sequence or timing of threads for it to operate properly

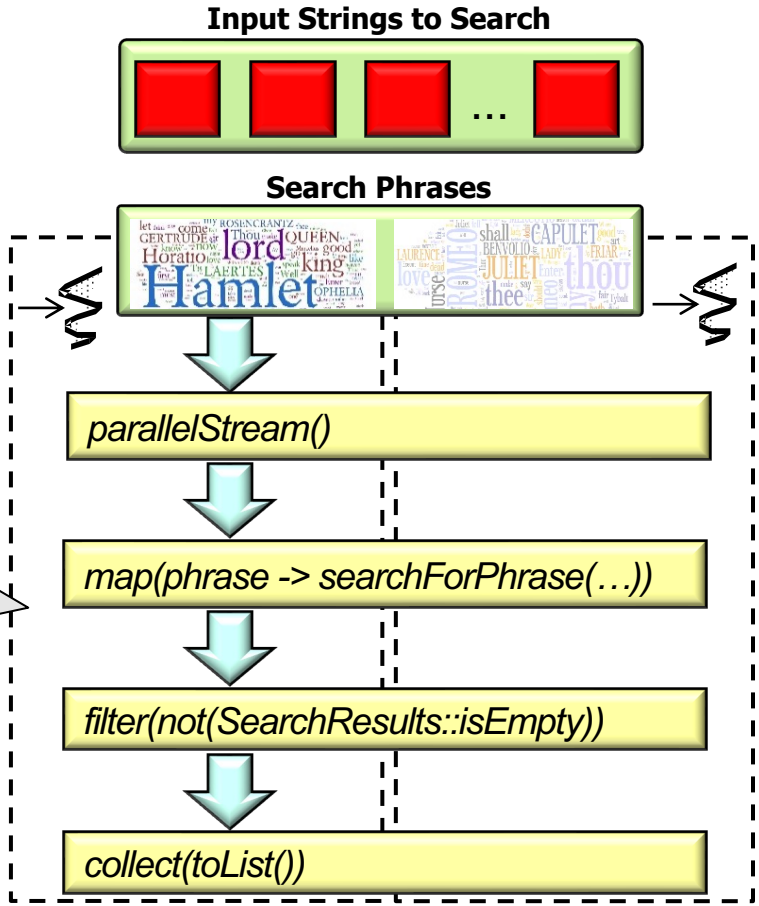




See en.wikipedia.org/wiki/Race_condition#Software

Avoiding Programming Hazards in Java Parallel Streams

- Thus avoid/minimize behaviors with side-effects in parallel streams



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

Avoiding Programming Hazards in Java Parallel Streams

- Thus avoid/minimize behaviors with side-effects in parallel streams, e.g.
  - *Stateful lambda expressions*
    - Where results depend on shared mutable state

```
class BuggyFactorial {
  static class Total {
    long mTotal = 1;
    void mult(long n)
    { mTotal *= n; }
  }

  static long factorial(long n){
    Total t = new Total();
    LongStream
      .rangeClosed(1, n)
      .parallel()
      .forEach(t::mult);

    return t.mTotal;
  } ...
```

See docs.oracle.com/javase/8/docs/api/java/util/stream/package-summary.html#Statelessness

Avoiding Programming Hazards in Java Parallel Streams

- Thus avoid/minimize behaviors with side-effects in parallel streams, e.g.
  - *Stateful lambda expressions*
    - Where results depend on shared mutable state
      - i.e., state that may change in parallel execution of a pipeline

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class BuggyFactorial {
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See github.com/douglascraigschmidt/LiveLessons/tree/master/Java8/ex16

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Incorrectly compute the factorial of param n using a parallel stream

```
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  }

  static long factorial(long n){
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      - i.e., state that may change in parallel execution of a pipeline

Define mutable state that's shared between threads in parallel stream

```
class BuggyFactorial {
  static class Total {
    long mTotal = 1;
    void mult(long n)
    { mTotal *= n; }
  }

  static long factorial(long n){
    Total t = new Total();
    LongStream
       .rangeClosed(1, n)
       .parallel()
       .forEach(t::mult);

    return t.mTotal;
  } ...
```

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    Total t = new Total();
    LongStream
       .rangeClosed(1, n)
       .parallel()
       .forEach(t::mult);

    return t.mTotal;
  } ...
```

Race conditions & inconsistent memory visibility may arise from the unsynchronized access to mTotal field

Avoiding Programming Hazards in Java Parallel Streams

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  - *Stateful lambda expressions*
    - Where results depend on shared mutable state
      - i.e., state that may change in parallel execution of a pipeline

```
class ParallelFactorial {
  static long factorial(long n){

    return LongStream
      .rangeClosed(1, n)

      .parallel()

      .reduce(1L,
              (x, y) -> x * y);
} ...
```

Using terminal operations like reduce() (or collect()) trivially addresses these problems!

See github.com/douglascraigschmidt/LiveLessons/tree/master/Java8/ex16

Avoiding Programming Hazards in Java Parallel Streams

- Thus avoid/minimize behaviors with side-effects in parallel streams, e.g.
  - *Stateful lambda expressions*
  - *Interference w/the data source*
    - Occurs when source of stream is modified within the pipeline


```
List<Integer> list = IntStream
   .range(0, 10)
   .boxed()
   .collect(toCollection
                (LinkedList::new));


list
   .parallelStream()
   .peek(list::remove)
   .forEach(System.out::println);
```

See docs.oracle.com/javase/8/docs/api/java/util/stream/package-summary.html#NonInterference

Avoiding Programming Hazards in Java Parallel Streams

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  - *Stateful lambda expressions*
  - *Interference w/the data source*
    - Occurs when source of stream is modified within the pipeline

```
List<Integer> list = IntStream
   .range(0, 10)
   .boxed()
   .collect(toCollection
                (LinkedList::new));
```

Create a list of ten integers in range 0..9

```
list
   .parallelStream()
   .peek(list::remove)
   .forEach(System.out::println);
```

See github.com/douglascraigschmidt/LiveLessons/tree/master/Java8/ex11

Avoiding Programming Hazards in Java Parallel Streams

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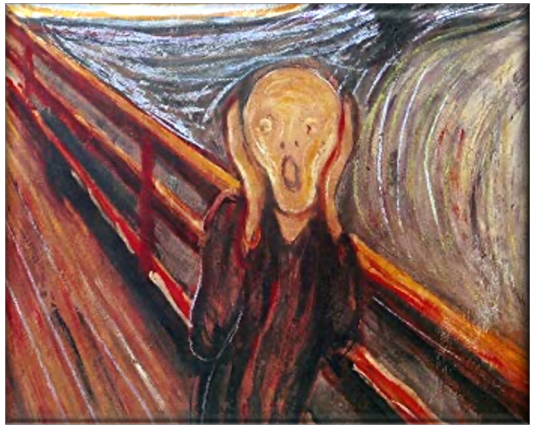

```
List<Integer> list = IntStream
   .range(0, 10)
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   .collect(toCollection
                (LinkedList::new));
```

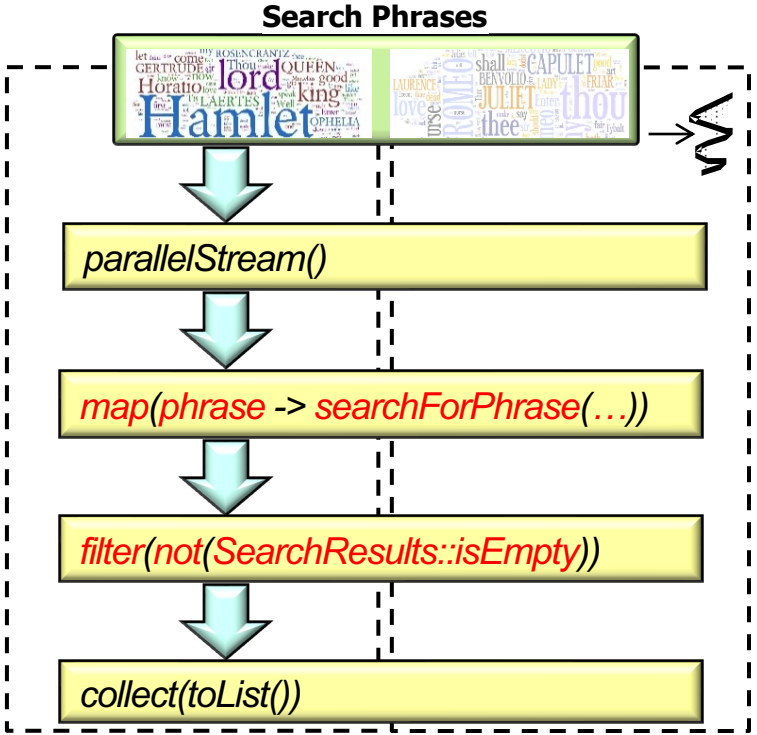
```
list
   .parallelStream()
   .peek(list::remove)
   .forEach(System.out::println);
```

If a non-concurrent collection is modified while it's being operated on by the parallel stream the results will be chao & insanity!!

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

Avoiding Programming Hazards in Java Parallel Streams

- Behaviors involving no shared state or side-effects are useful for parallel streams since they needn't be synchronized explicitly



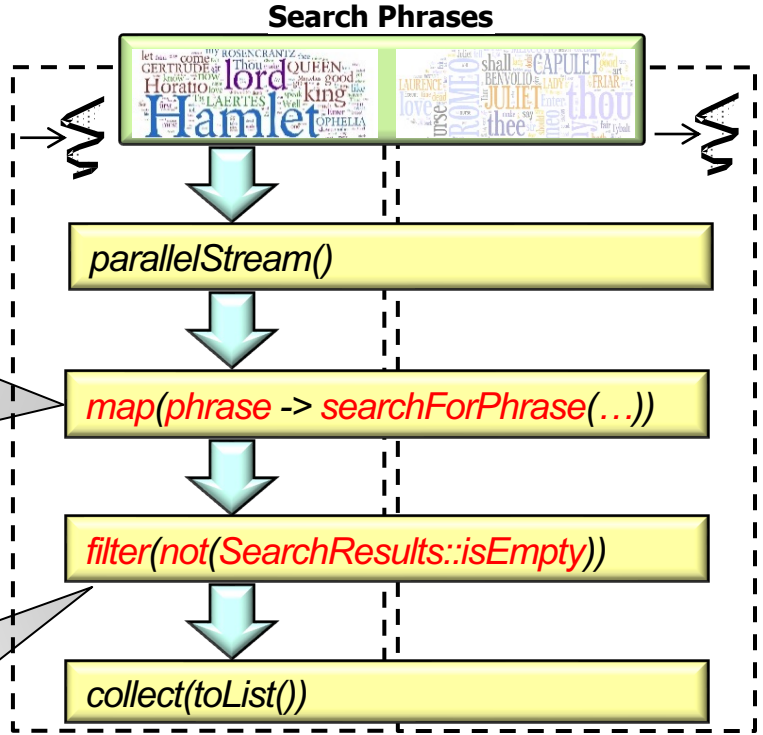
See henrikeichenhardt.blogspot.com/2013/06/why-shared-mutable-state-is-root-of-all.html

Avoiding Programming Hazards in Java Parallel Streams

- Behaviors involving no shared state or side-effects are useful for parallel streams since they needn't be synchronized explicitly
  - e.g., Java lambda expressions & method references that are "pure functions"

```
return new SearchResults
   (Thread.currentThread().getId(),
    currentCycle(), phrase, title,
    StreamSupport
      .stream(new PhraseMatchSpliterator
                    (input, phrase),
              parallel)
      .collect(toList()));
```

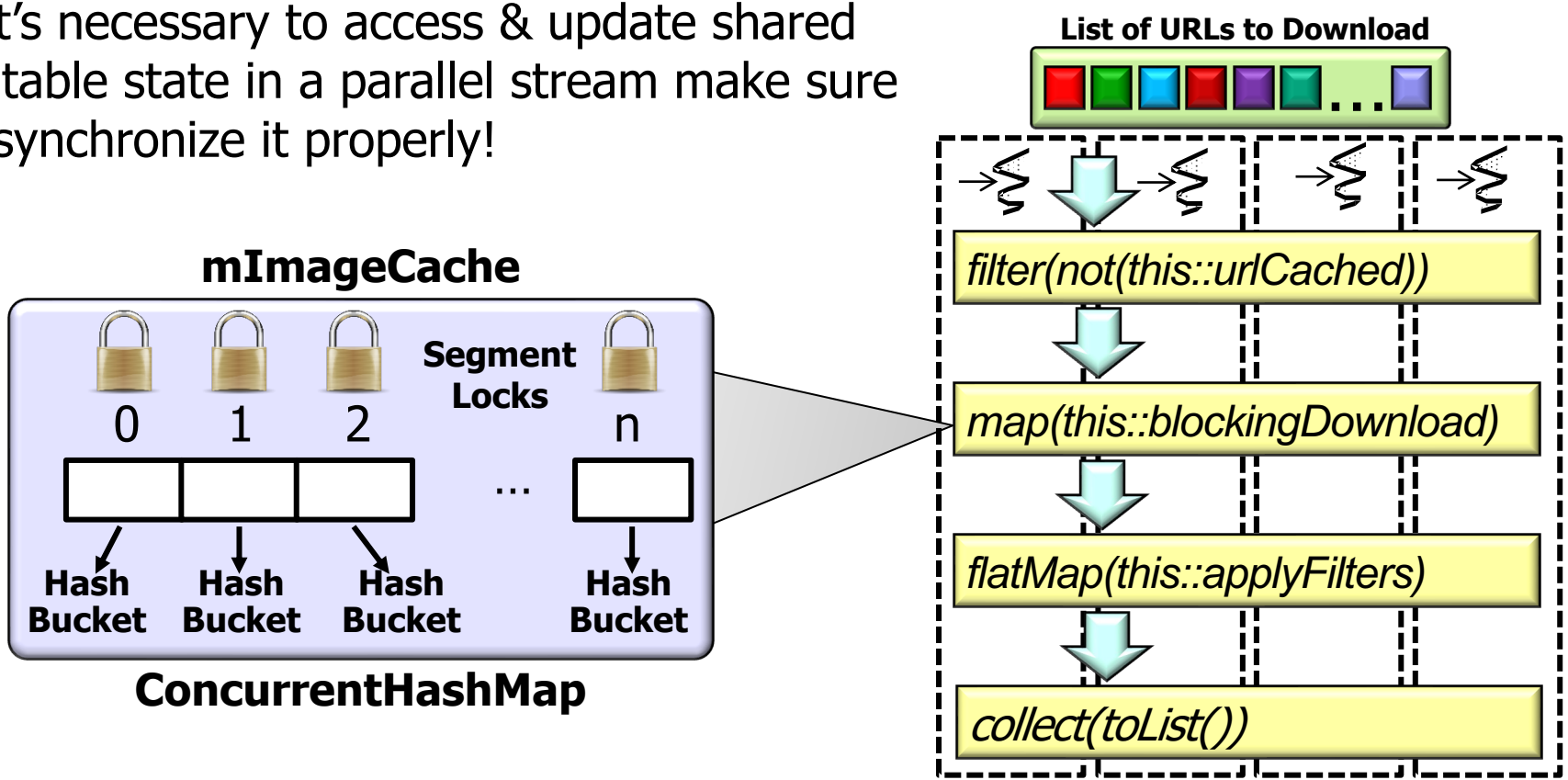
```
return mList.size() == 0;
```



See en.wikipedia.org/wiki/Pure_function

Avoiding Programming Hazards in Java Parallel Streams

- If it's necessary to access & update shared mutable state in a parallel stream make sure to synchronize it properly!



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

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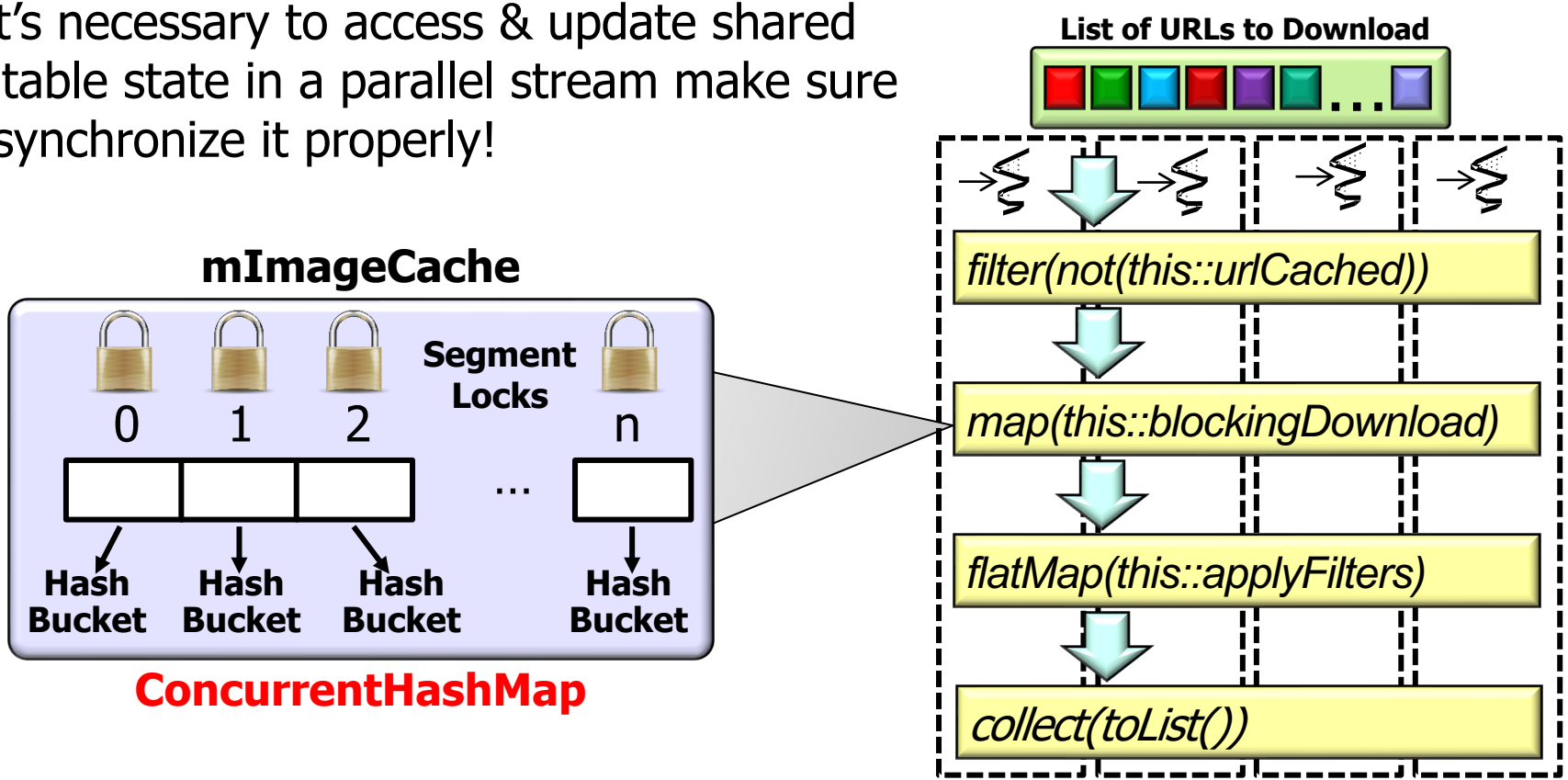

See docs.oracle.com/javase/8/docs/api/java/util/concurrent/ConcurrentHashMap.html

End of Avoiding Programming Hazards with Java Parallel Streams