Overview of Java Parallelism Frameworks

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Learning Objectives in this Lesson

- Recognize the parallelism frameworks supported by Java

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  - **Fork-join pools**
    - An object-oriented framework

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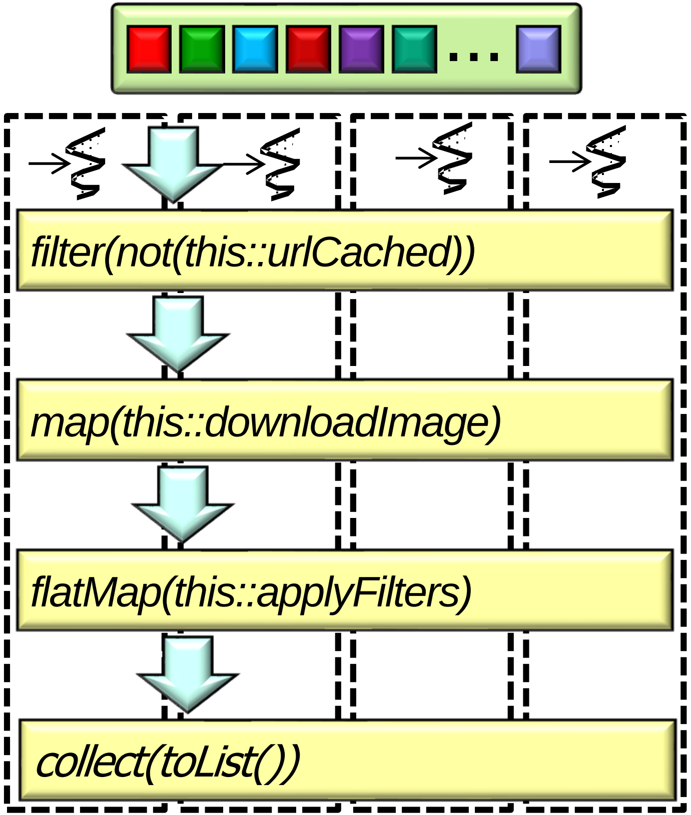
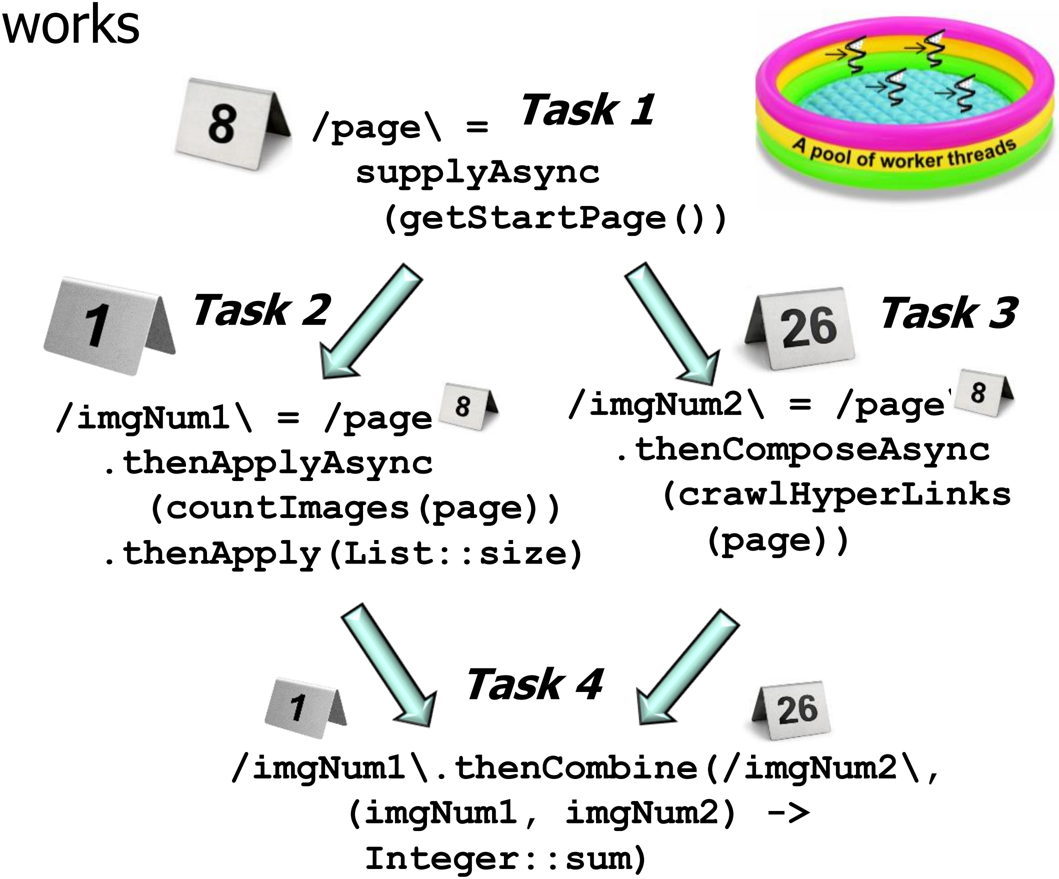
  - **Fork-join pools**
  - **Parallel streams**
    - A synchronous functional framework



Learning Objectives in this Lesson

- Recognize the parallelism frameworks supported by Java, e.g.
  - Fork-join pools
  - Parallel streams
  - **Completable futures**
    - A reactive/asynchronous functional framework



```
/page\ =
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```

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/imgNum1\ = /page
  .thenApplyAsync
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/imgNum2\ = /page
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```

```
/imgNum1\.thenCombine(/imgNum2\,
     (imgNum1, imgNum2) ->
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Overview of Java Parallelism Frameworks

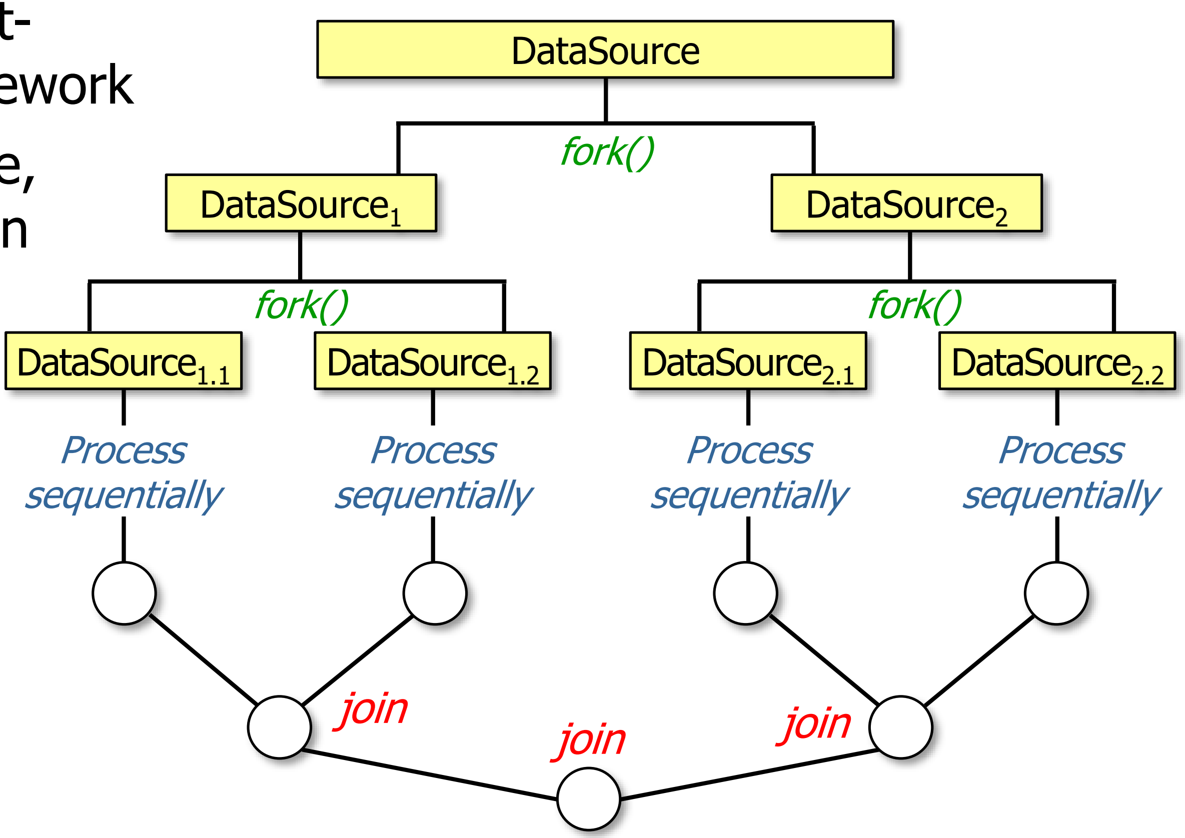
Overview of Java Parallelism Frameworks

- Java 7 introduced the object-oriented fork-join pool framework

See www.infoq.com/interviews/doug-lea-fork-join

Overview of Java Parallelism Frameworks

- Java 7 introduced the object-oriented fork-join pool framework
  - Provides high performance, fine-grained task execution for data parallelism

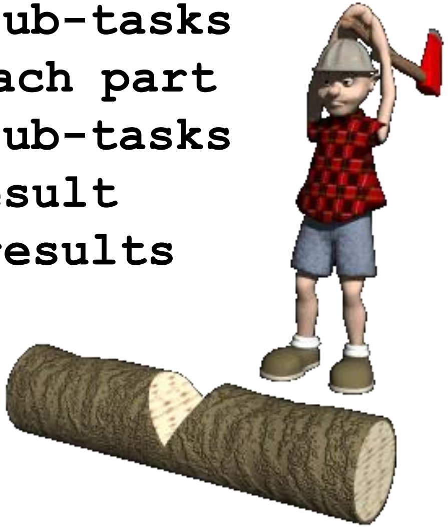


See www.dre.vanderbilt.edu/~schmidt/PDF/DataParallelismInJava.pdf

Overview of Java Parallelism Frameworks

- Java 7 introduced the object-oriented fork-join pool framework
  - Provides high performance, fine-grained task execution for data parallelism
  - Supports parallel programming by solving problems via "divide & conquer"

```
Result solve(Problem problem) {
  if (problem is small)
    directly solve problem
  else {
    a. split problem into
       independent parts
    b. fork new sub-tasks
       to solve each part
    c. join all sub-tasks
    d. compose result
       from sub-results
  }
}
```



See en.wikipedia.org/wiki/Divide_and_conquer_algorithm

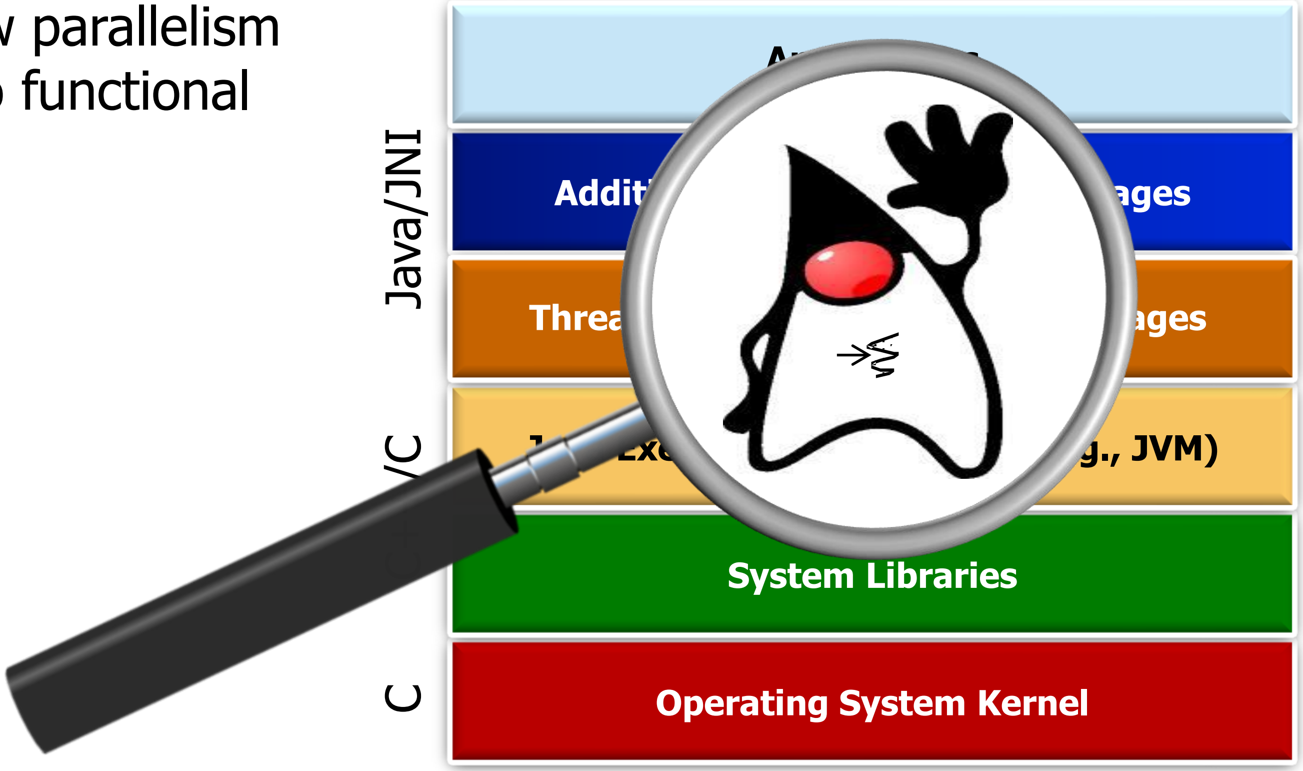
Overview of Java Parallelism Frameworks

- Java 7 introduced the object-oriented fork-join pool framework
  - Provides high performance, fine-grained task execution for data parallelism
  - Supports parallel programming by solving problems via "divide & conquer"
  - Employs *work-stealing* to maximize multi-core processor performance

See gee.cs.oswego.edu/dl/papers/fj.pdf

Overview of Java Parallelism Frameworks

- Java 8 added two new parallelism frameworks related to functional programming

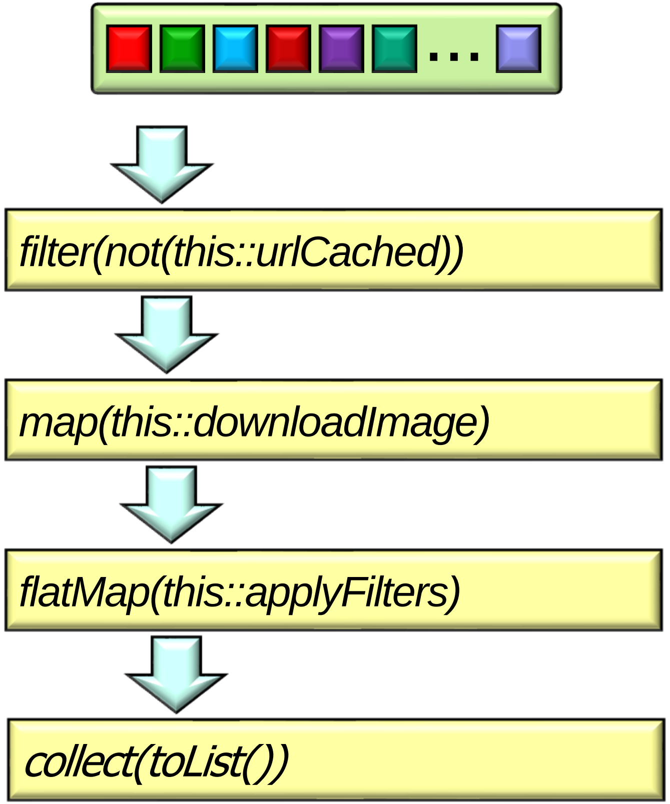


See www.ibm.com/developerworks/library/j-jvmc2

Overview of Java Parallelism Frameworks

- Java 8 added two new parallelism frameworks related to functional programming

  1. Parallel streams



filter(not(this::urlCached))

map(this::downloadImage)

flatMap(this::applyFilters)

collect(toList())

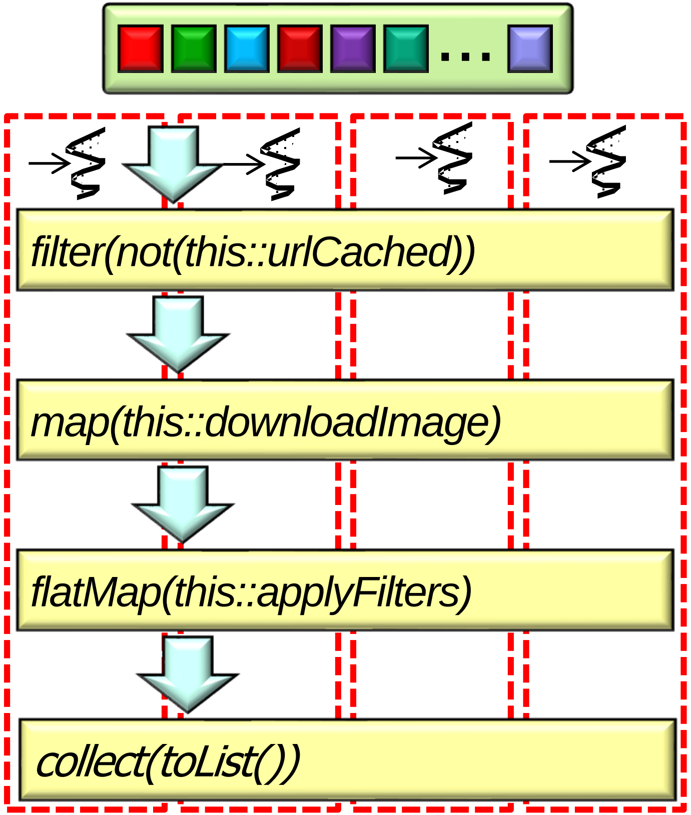
See docs.oracle.com/javase/tutorial/collections/streams/parallelism.html

Overview of Java Parallelism Frameworks

- Java 8 added two new parallelism frameworks related to functional programming

  1. Parallel streams

  - Partitions a stream into multiple substreams that run independently & combine into a "reduced" result

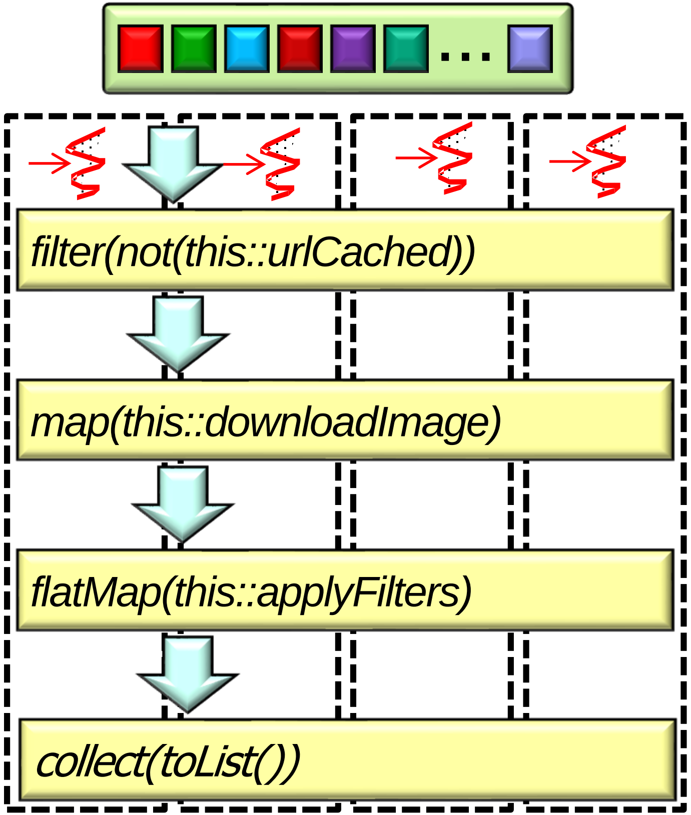


Overview of Java Parallelism Frameworks

- Java 8 added two new parallelism frameworks related to functional programming

  1. Parallel streams

  - Partitions a stream into multiple substreams that run independently & combine into a "reduced" result
  - Chunks of data in the substreams can be mapped to multiple threads (& cores)



Overview of Java Parallelism Frameworks

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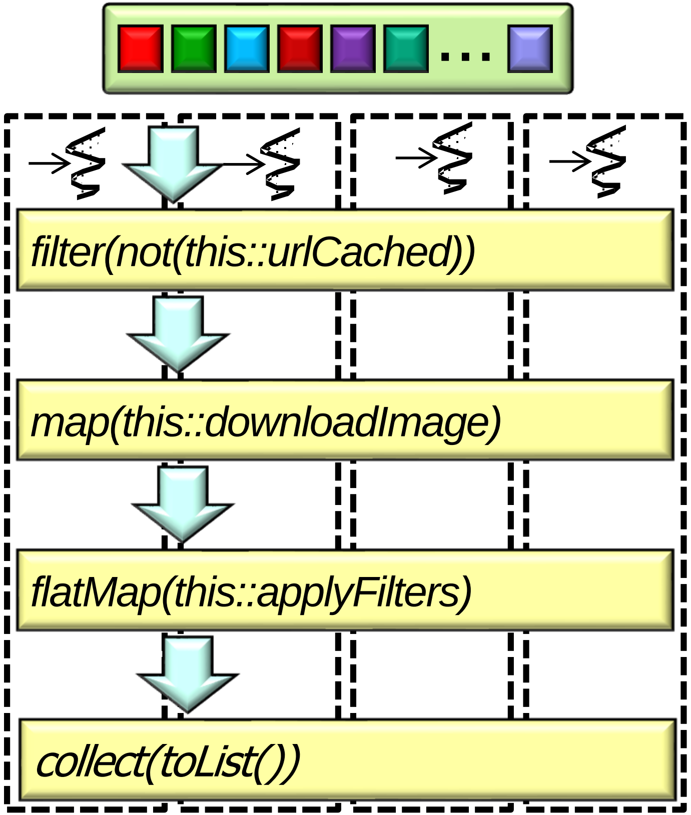
1. Parallel streams

  - Partitions a stream into multiple substreams that run independently & combine into a "reduced" result
  - Chunks of data in the substreams can be mapped to multiple threads (& cores)
  - Leverages the common fork-join pool



See dzone.com/articles/common-fork-join-pool-and-streams

Overview of Java Parallelism Frameworks

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1. Parallel streams

- Partitions a stream into multiple substreams that run independently & combine into a "reduced" result
- Chunks of data in the substreams can be mapped to multiple threads (& cores)
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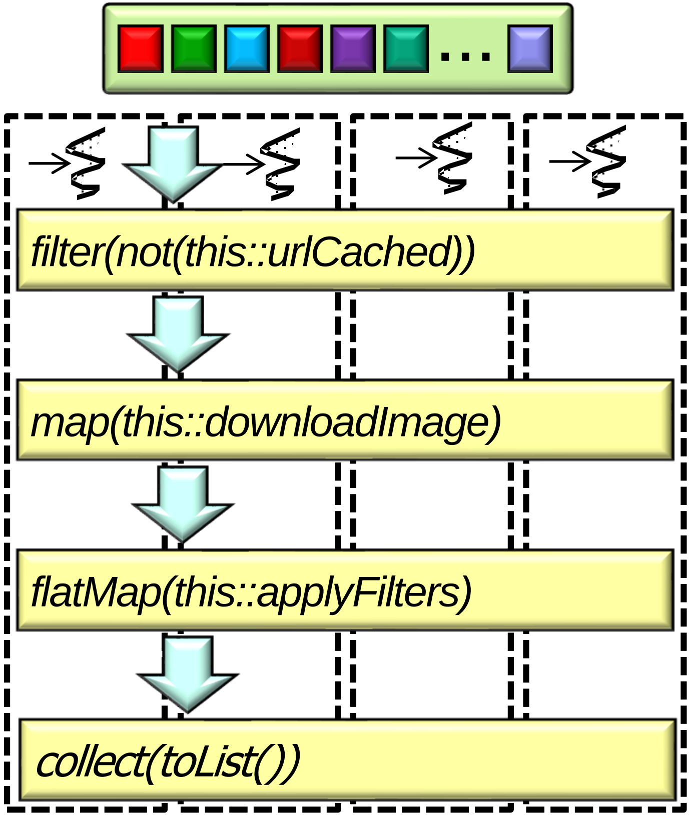

Parallel streams provides fine-grained data parallelism functional programming

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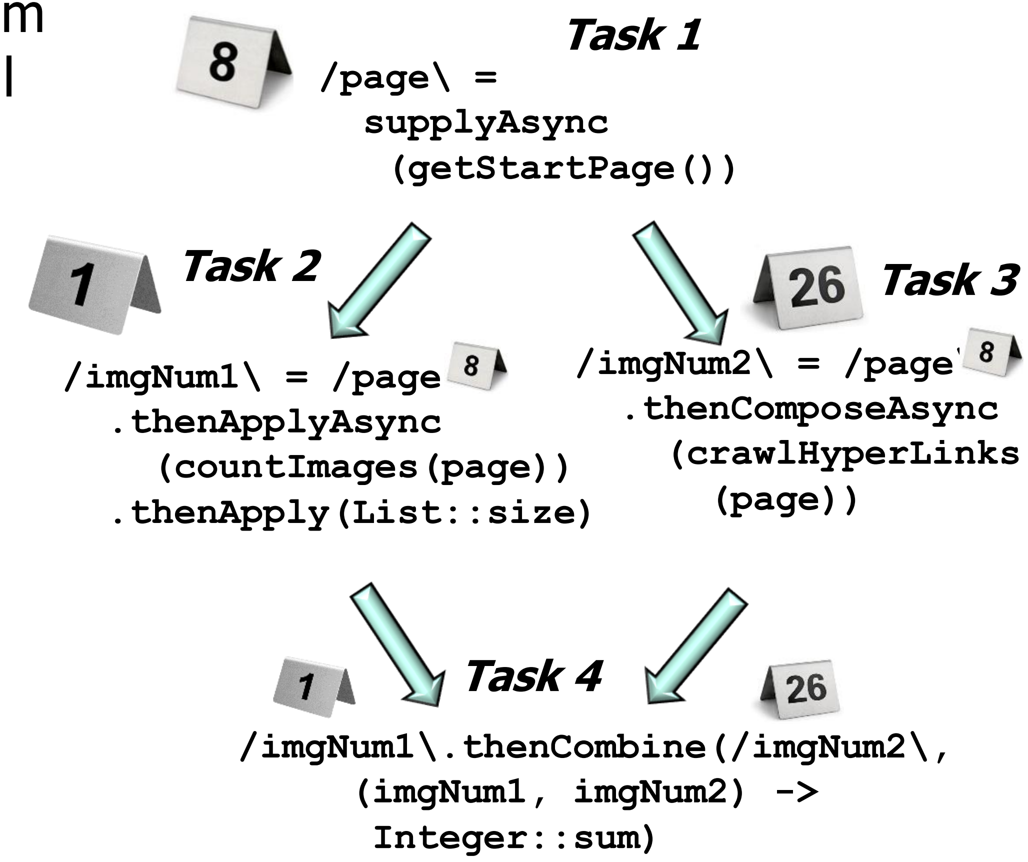
1. Parallel streams
2. **Completable futures**



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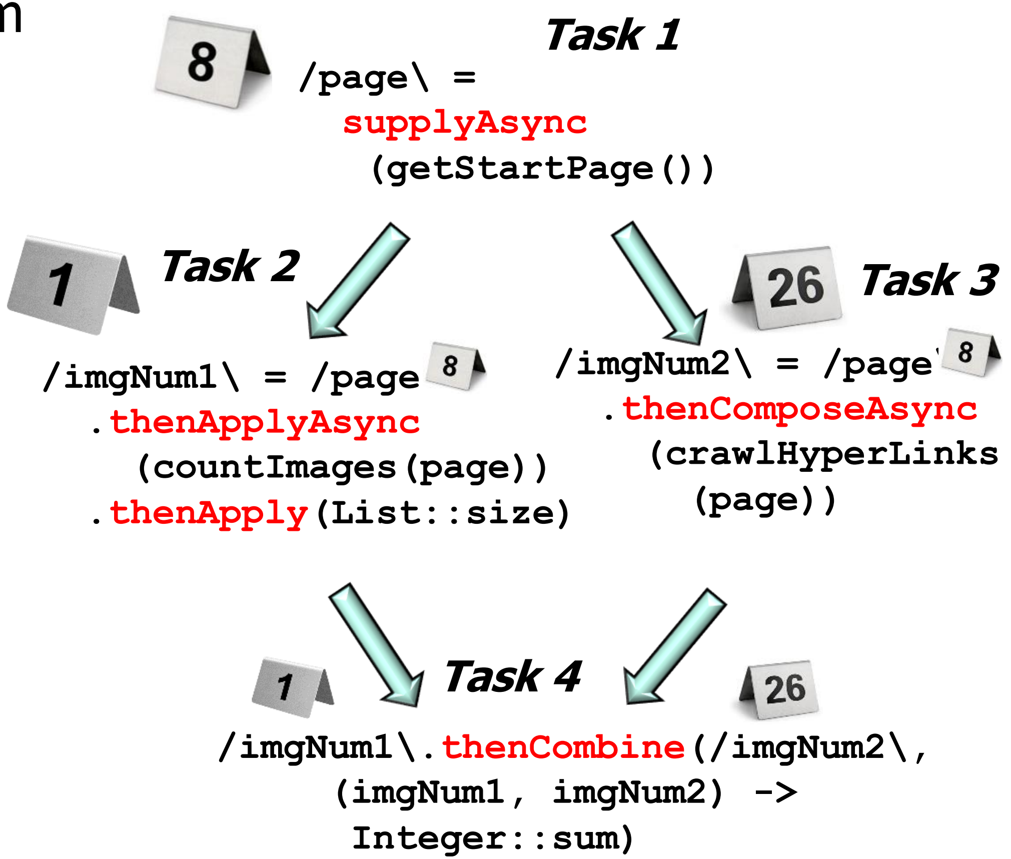
See docs.oracle.com/javase/8/docs/api/java/util/concurrent/CompletableFuture.html

Overview of Java Parallelism Frameworks

- Java 8 added two new parallelism frameworks related to functional programming

  1. **Parallel streams**
  2. **Completable futures**
     - Supports dependent actions that trigger upon completion of async operations



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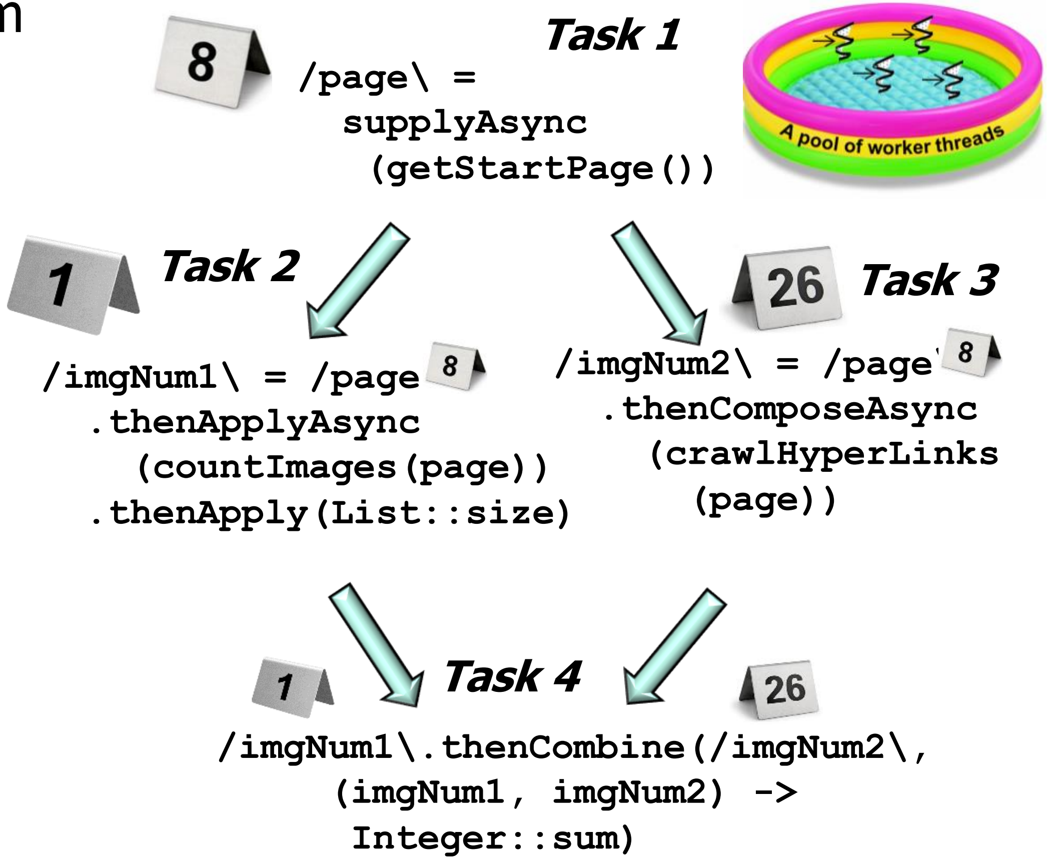
See docs.oracle.com/javase/8/docs/api/java/util/concurrent/CompletionStage.html

Overview of Java Parallelism Frameworks

- Java 8 added two new parallelism frameworks related to functional programming
  1. Parallel streams
  2. **Completable futures**
     - Supports dependent actions that trigger upon completion of async operations
     - Async operations can run in parallel in thread pools



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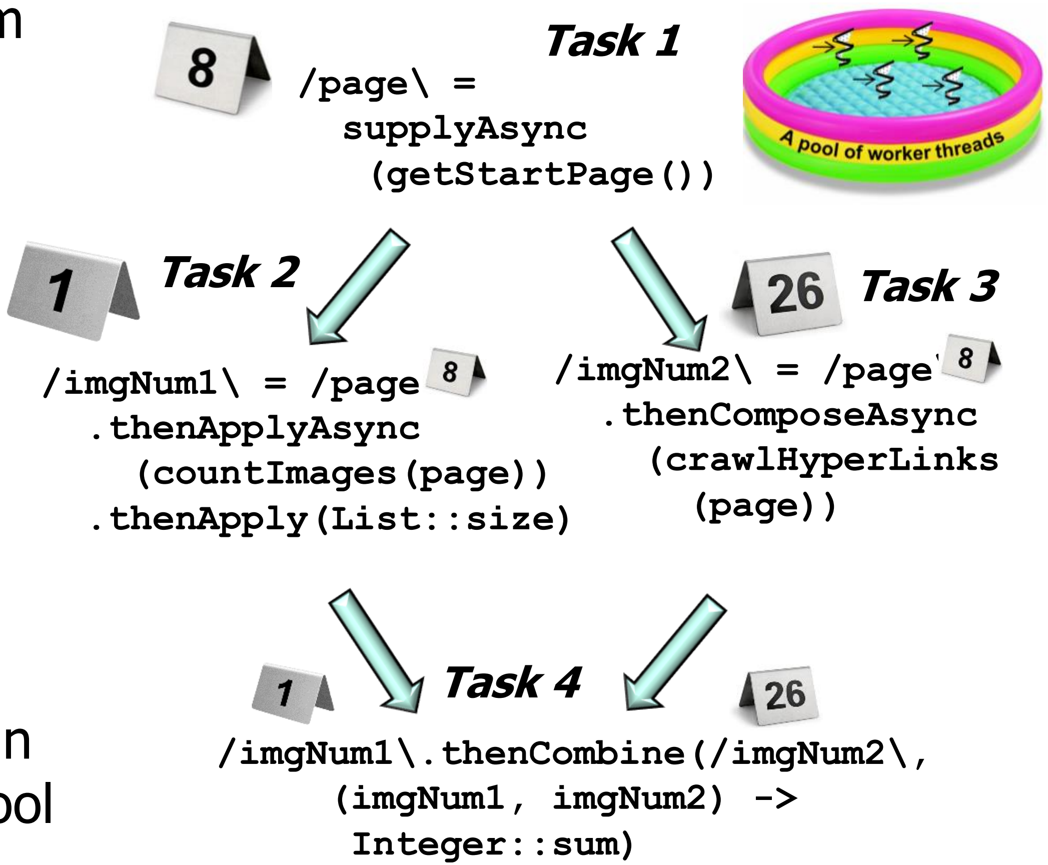
See www.nurkiewicz.com/2013/05/java-8-definitive-guide-to.html

Overview of Java Parallelism Frameworks

- Java 8 added two new parallelism frameworks related to functional programming
  1. **Parallel streams**
  2. **Completable futures**
     - Supports dependent actions that trigger upon completion of async operations
     - Async operations can run in parallel in thread pools
       - Either the common fork-join pool or a custom thread pool



Task 1

```
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Task 2

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Task 3

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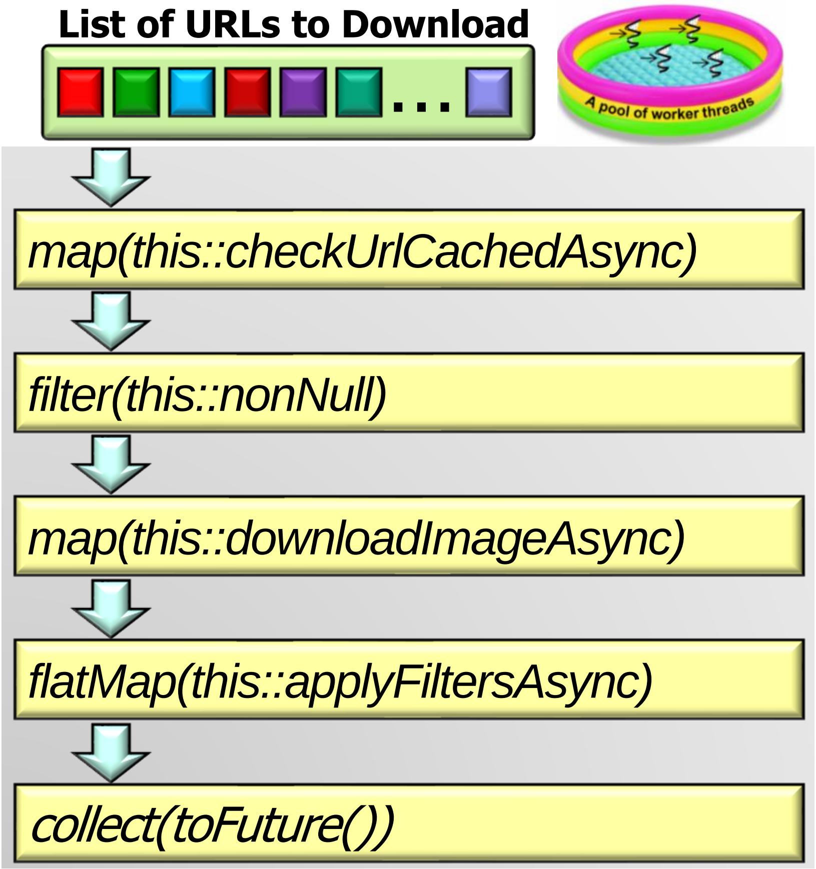


List of URLs to Download

map(this::checkUrlCachedAsync)

filter(this::nonNull)

map(this::downloadImageAsync)

flatMap(this::applyFiltersAsync)

collect(toFuture())

Java completable futures & streams can be combined to good effects!!

Overview of Java Parallelism Frameworks

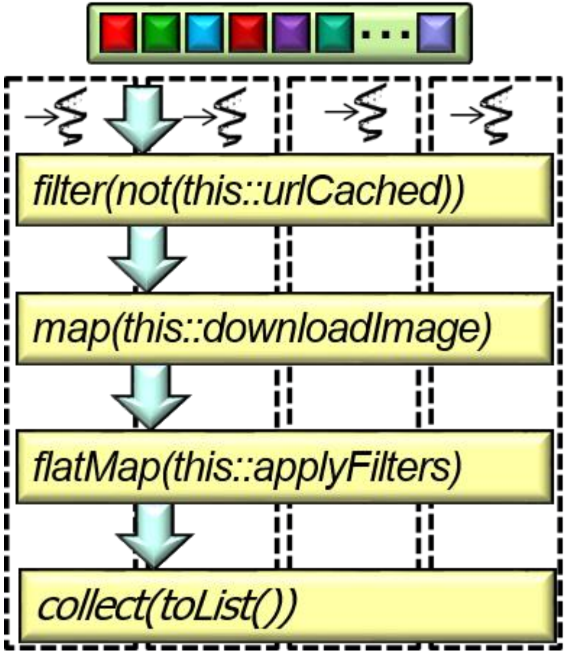
- These Java frameworks often eliminate the use of synchronization or explicit threading when developing parallel apps!

Alleviates many accidental & inherent complexities of parallel programming

Overview of Java Parallelism Frameworks

- Java parallel streams & completable future functional frameworks use the object-oriented fork-join pool framework by default

Parallel Streams



filter(not(this::urlCached))

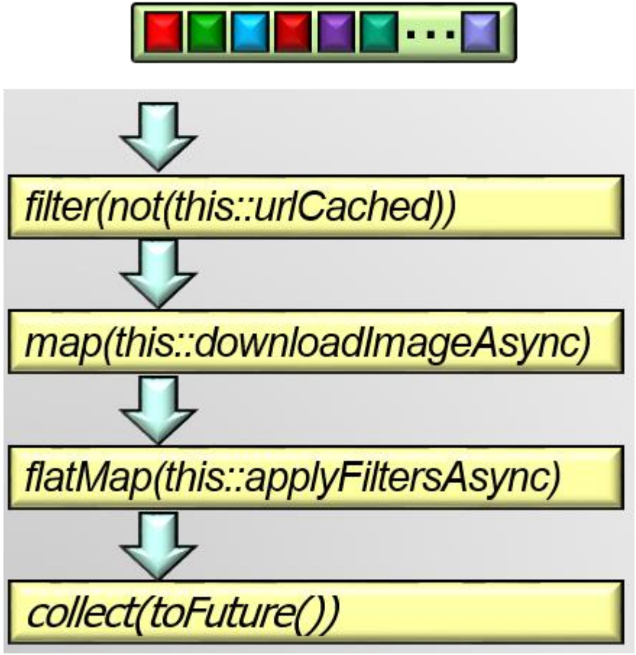
map(this::downloadImage)

flatMap(this::applyFilters)

collect(toList())

ForkJoinPool

Completable Futures



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See www.oracle.com/technetwork/articles/java/fork-join-422606.html

End of Overview of Java Parallelism Frameworks