Overview of Java 8 CompletableFutures (Part 1)

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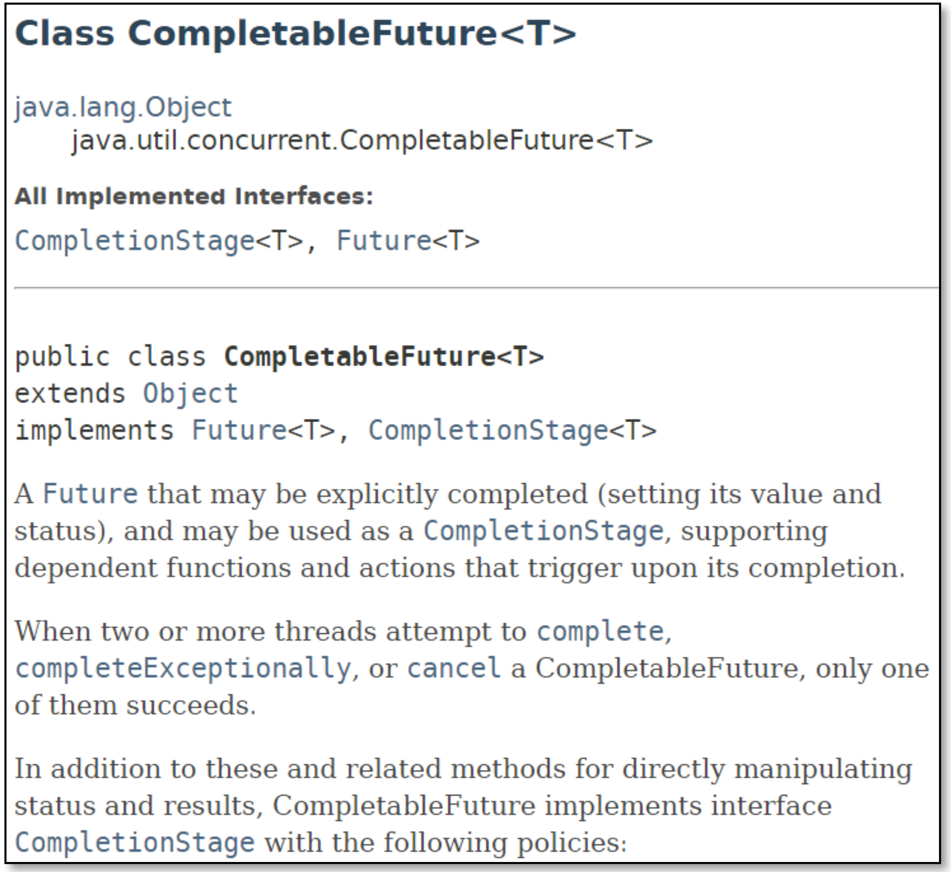
Learning Objectives in this Part of the Lesson

- Recognize key basic & advanced features of the Java 8 completable future framework



Class CompletableFuture<T>

java.lang.Object
    java.util.concurrent.CompletableFuture<T>

All Implemented Interfaces:

CompletionStage<T>, Future<T>

```
public class CompletableFuture<T>
extends Object
implements Future<T>, CompletionStage<T>
```

A Future that may be explicitly completed (setting its value and status), and may be used as a CompletionStage, supporting dependent functions and actions that trigger upon its completion.

When two or more threads attempt to complete, completeExceptionally, or cancel a CompletableFuture, only one of them succeeds.

In addition to these and related methods for directly manipulating status and results, CompletableFuture implements interface CompletionStage with the following policies:

Overview of Completable Futures

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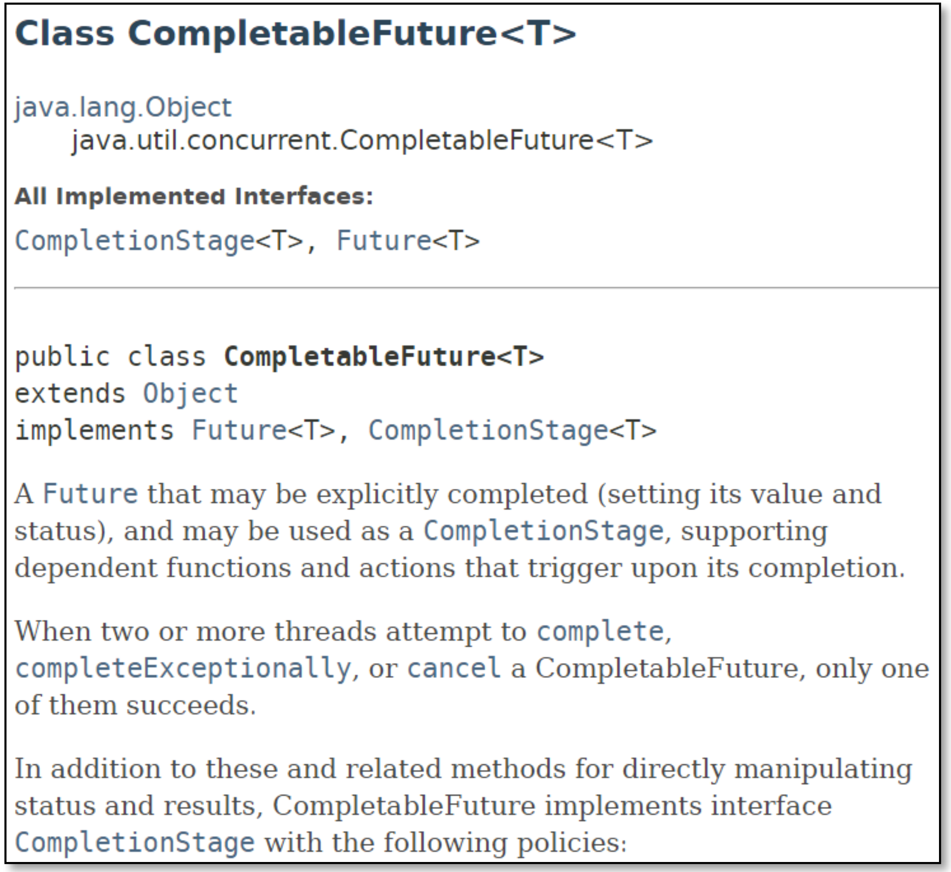
- The Java 8 completable future framework provides an async concurrent programming model



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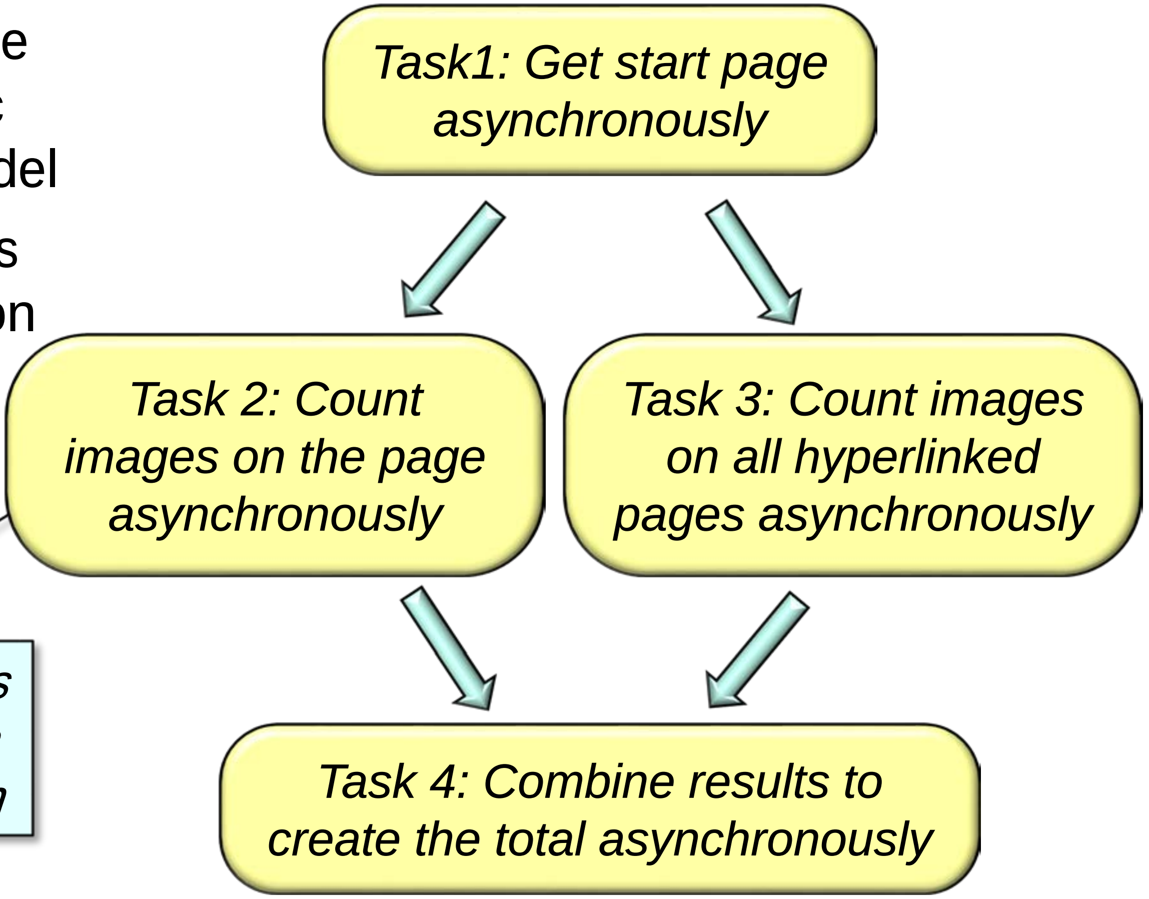
See docs.oracle.com/javase/8/docs/api/java/util/concurrent/CompletableFuture.html

Overview of Completable Futures

- The Java 8 completable future framework provides an async concurrent programming model
  - Supports dependent actions that trigger upon completion of async operations



Task1: Get start page asynchronously
Task 2: Count images on the page asynchronously
Task 3: Count images on all hyperlinked pages asynchronously
Task 4: Combine results to create the total asynchronously

These dependencies can be modeled via a data flow diagram

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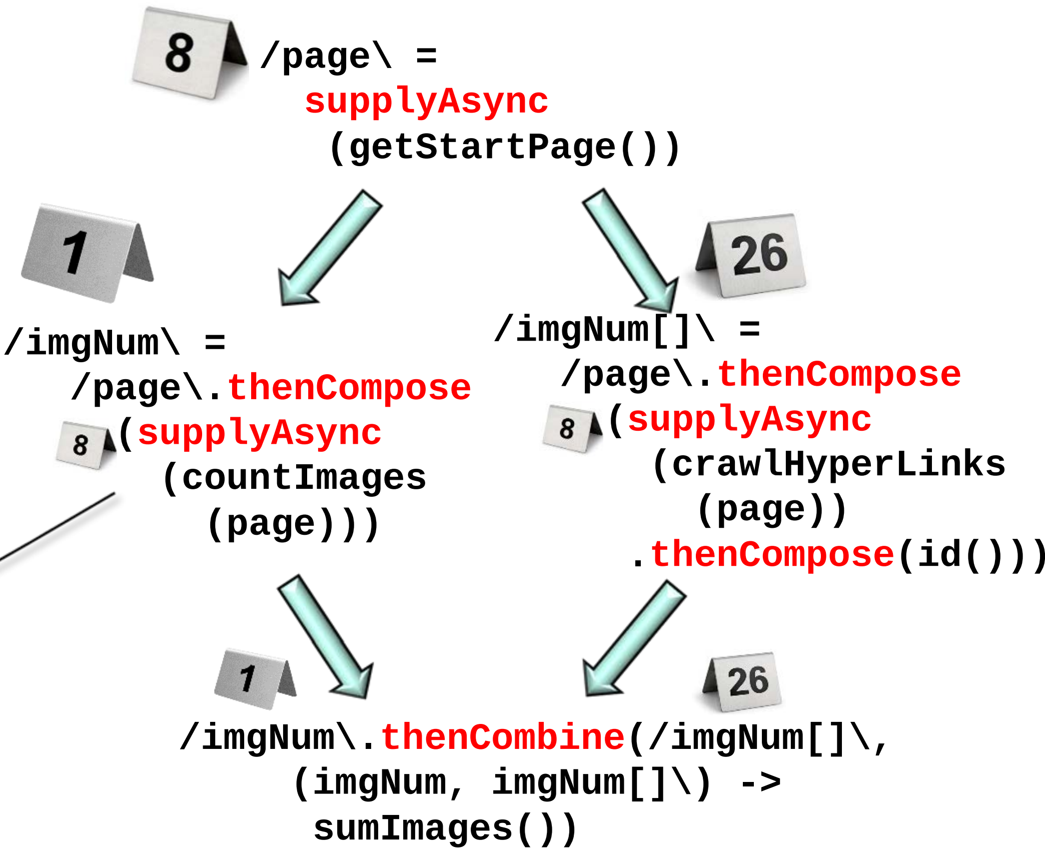

```
/page\ =
  supplyAsync
   (getStartPage())

/imgNum\ =
   /page\.thenCompose
     (supplyAsync
       (countImages
         (page)))

/imgNum[]\ =
   /page\.thenCompose
    (supplyAsync
      (crawlHyperLinks
        (page))
     .thenCompose(id()))

/imgNum\.thenCombine(/imgNum[]\,
     (imgNum, imgNum[]\) ->
      sumImages())
```

Async operations can be forked, chained, & joined

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

Overview of Completable Futures

- The Java 8 completable future framework provides an async concurrent programming model
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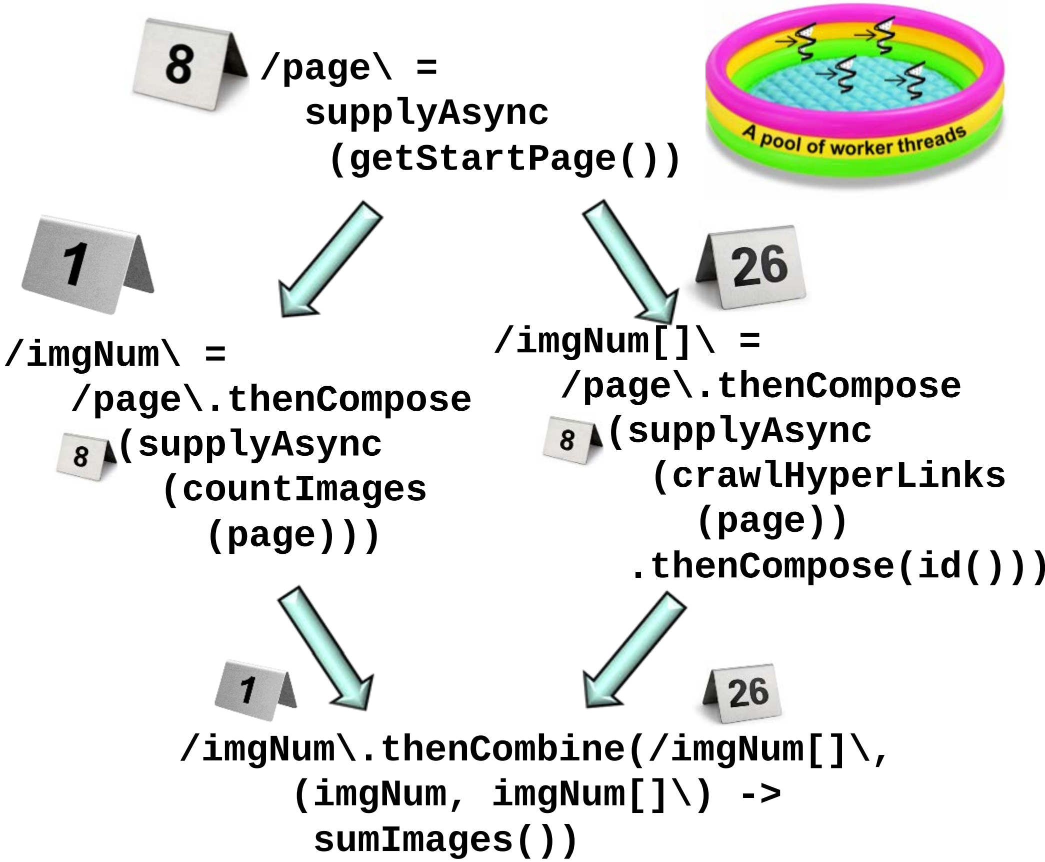
  - Async operations can run concurrently in thread pools



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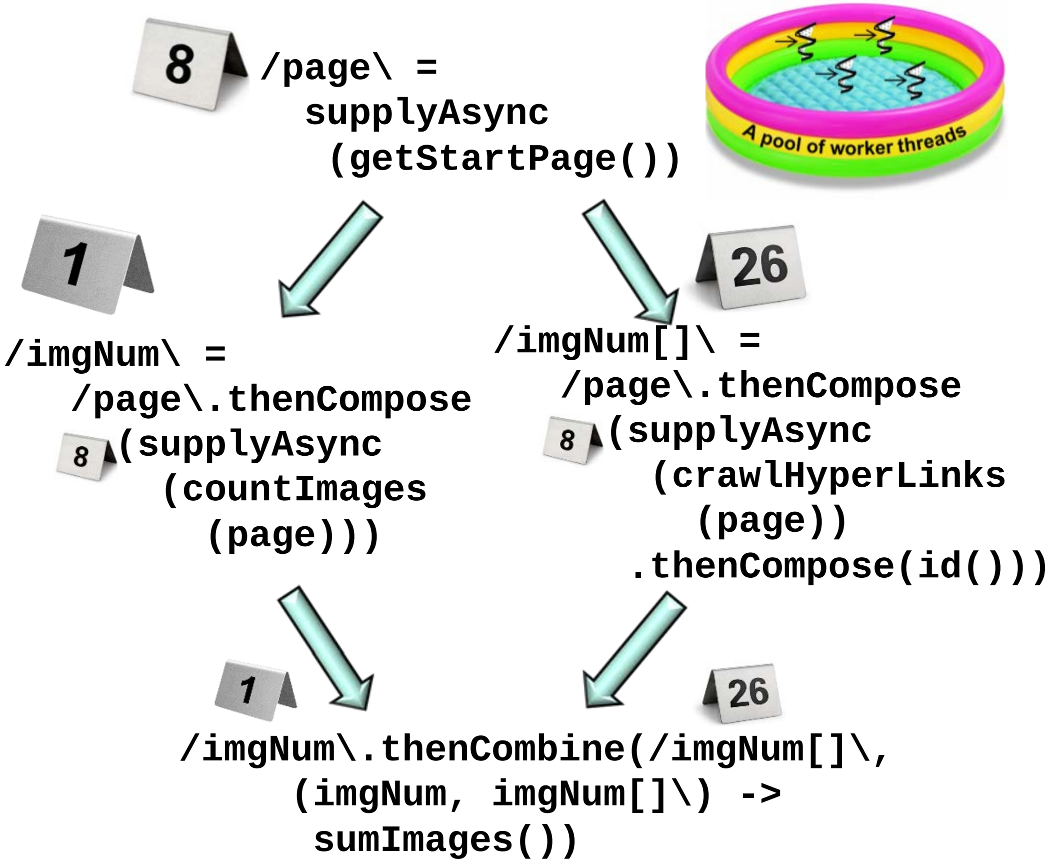
See www.nurkiewicz.com/2013/05/java-8-definitive-guide-to.html

Overview of Completable Futures

- The Java 8 completable future framework provides an async concurrent programming model
  - Supports dependent actions that trigger upon completion of async operations
  - Async operations can run concurrently in thread pools
    - Either the common fork-join pool or a user-designed pool



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Overview of Completable Futures

- The completable future framework overcomes Java future limitations

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

Overview of Completable Futures

- The completable future framework overcomes Java future limitations
  - *Can* be completed explicitly

```
CompletableFuture<...> future =
  new CompletableFuture<>();

new Thread (() -> {
  ...
  future.complete(...);
}).start();

...
System.out.println(future.join());
```

After complete() is done calls to join() will unblock

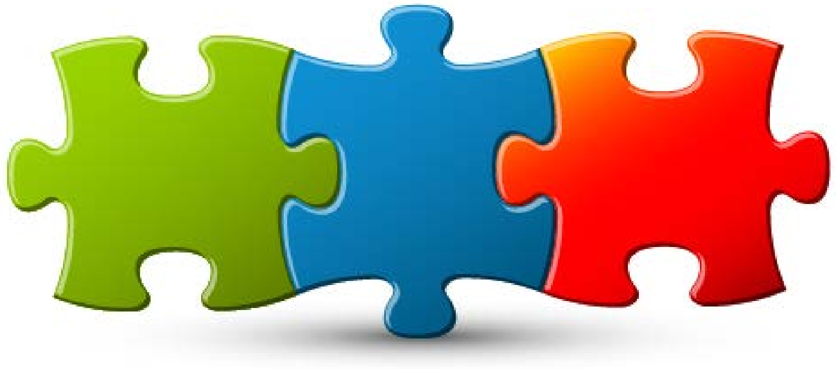
See github.com/douglascraigschmidt/LiveLessons/tree/master/Java8/ex8

Overview of Completable Futures

- The completable future framework overcomes Java future limitations
  - *Can* be completed explicitly
  - *Can* be chained together fluently to handle async results efficiently

```
CompletableFuture
  .supplyAsync(reduceFraction)
  .thenApply(BigFraction
               ::toMixedString)
  .thenAccept(System.out::println);
```

The action of each "completion stage" is triggered when the future from the previous stage completes asynchronously



See en.wikipedia.org/wiki/Fluent_interface

Overview of Completable Futures

- The completable future framework overcomes Java future limitations
  - *Can* be completed explicitly
  - *Can* be chained together fluently to handle async results efficiently
  - *Can* be triggered reactively/ efficiently as a *collection* of futures w/out undue overhead

```
CompletableFuture<List
   <BigFraction>> futureToList =
   Stream
      .generate(generator)
      .limit(sMAX_FRACTIONS)
      .map(reduceFractions)
      .collect(FuturesCollector
                   .toFutures());
futureToList
   .thenAccept(printList);
```

Print out the results after all async fraction reductions have completed

Overview of Completable Futures

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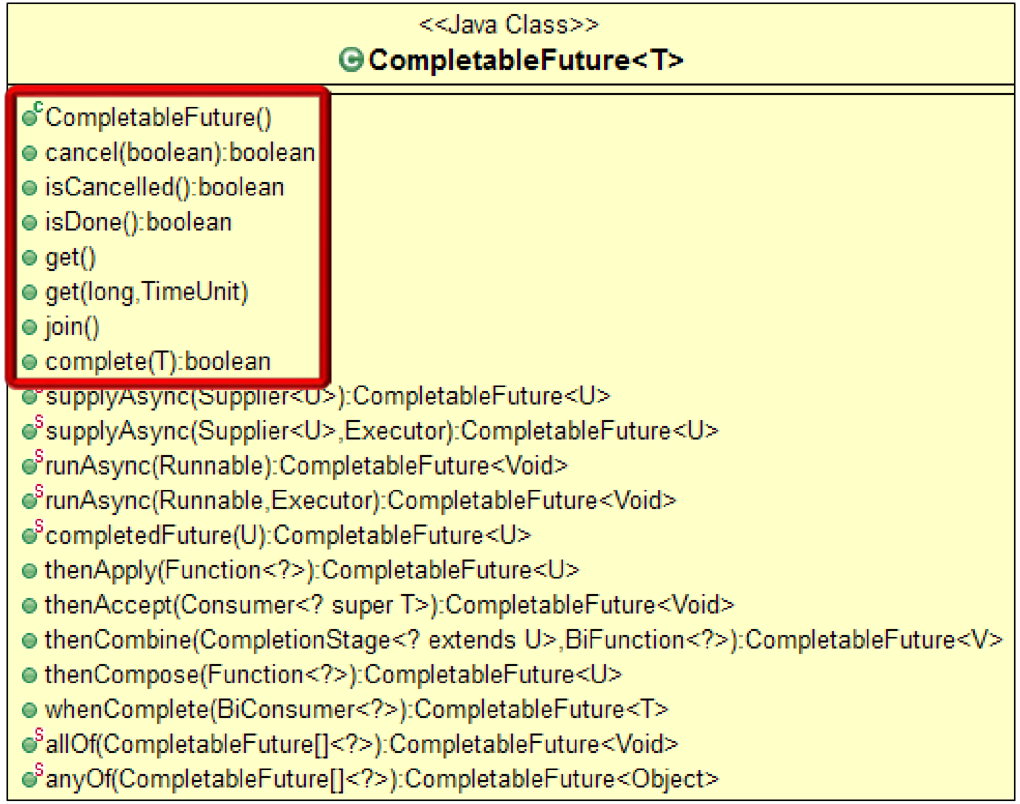
Completable futures can also be combined with Java 8 streams

Overview of Completable Futures

- Some completable future features are basic



<<Java Class>>

CompletableFuture<T>

- CompletableFuture()
- cancel(boolean):boolean
- isCancelled():boolean
- isDone():boolean
- get()
- get(long,TimeUnit)
- join()
- complete(T):boolean
- supplyAsync(Supplier<U>):CompletableFuture<U>
- supplyAsync(Supplier<U>,Executor):CompletableFuture<U>
- runAsync(Runnable):CompletableFuture<Void>
- runAsync(Runnable,Executor):CompletableFuture<Void>
- completedFuture(U):CompletableFuture<U>
- thenApply(Function<?>):CompletableFuture<U>
- thenAccept(Consumer<? super T>):CompletableFuture<Void>
- thenCombine(CompletionStage<? extends U>,BiFunction<?>):CompletableFuture<V>
- thenCompose(Function<?>):CompletableFuture<U>
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- allOf(CompletableFuture[]<?>):CompletableFuture<Void>
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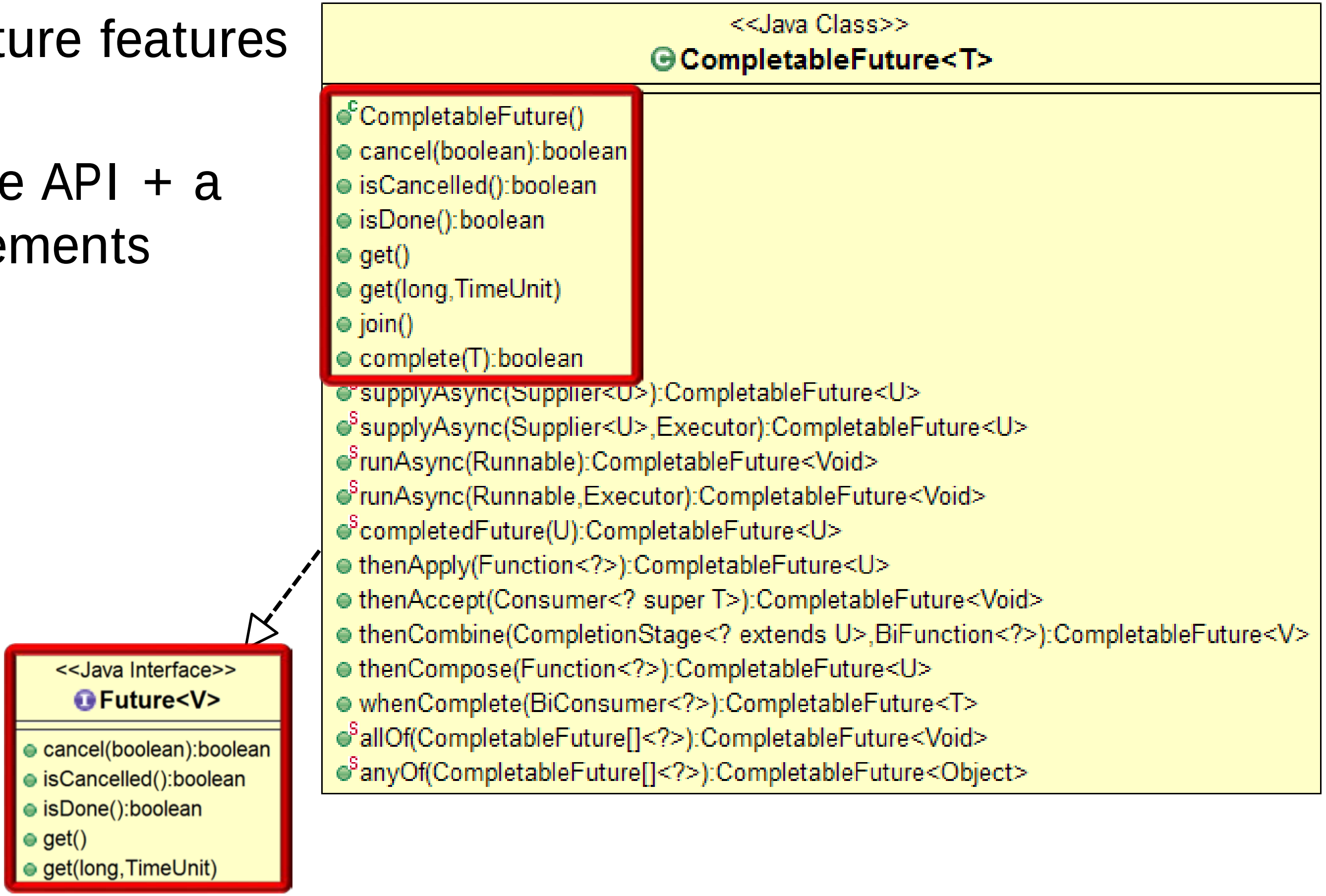
Overview of Completable Futures

- Some completable future features are basic
  - e.g., the Java Future API + a few simple enhancements



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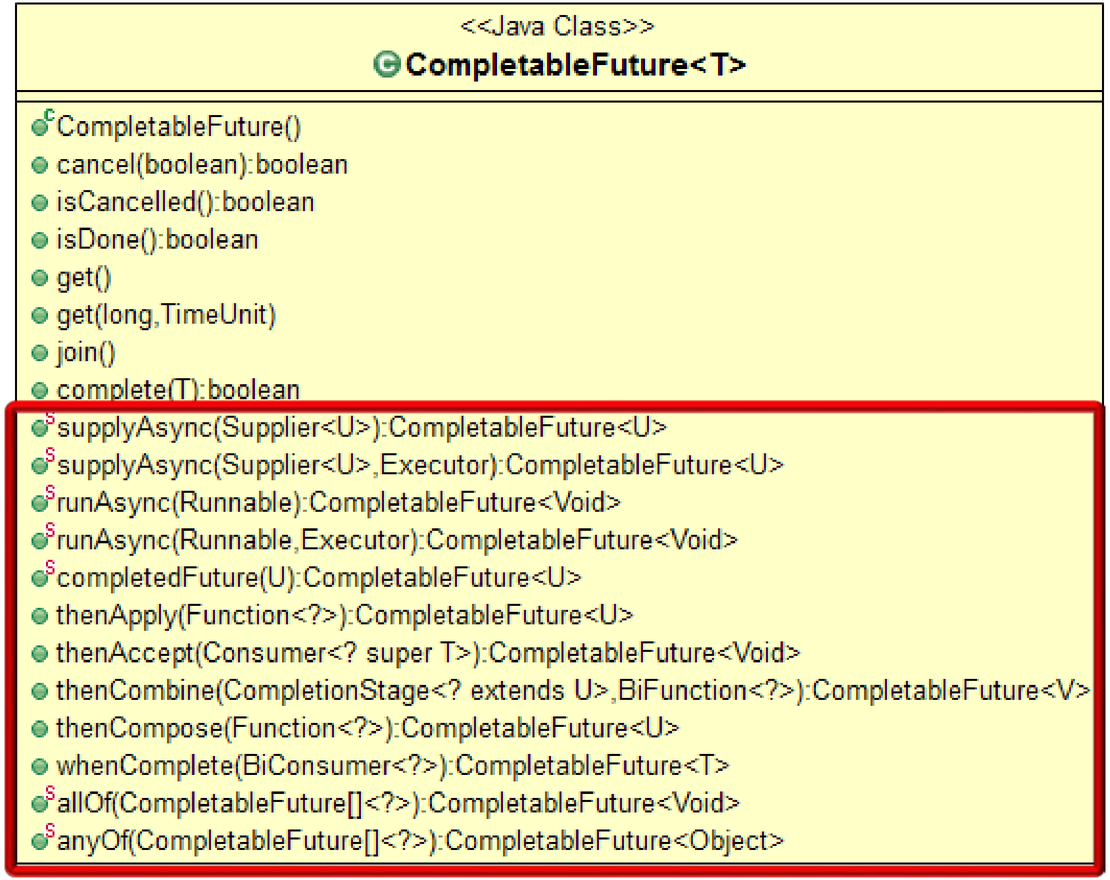
<<Java Interface>>
Future<V>

```
cancel(boolean):boolean
isCancelled():boolean
isDone():boolean
get()
get(long,TimeUnit)
```

Only slightly better than the conventional Future interface

Overview of Completable Futures

- Other completable future features are more advanced



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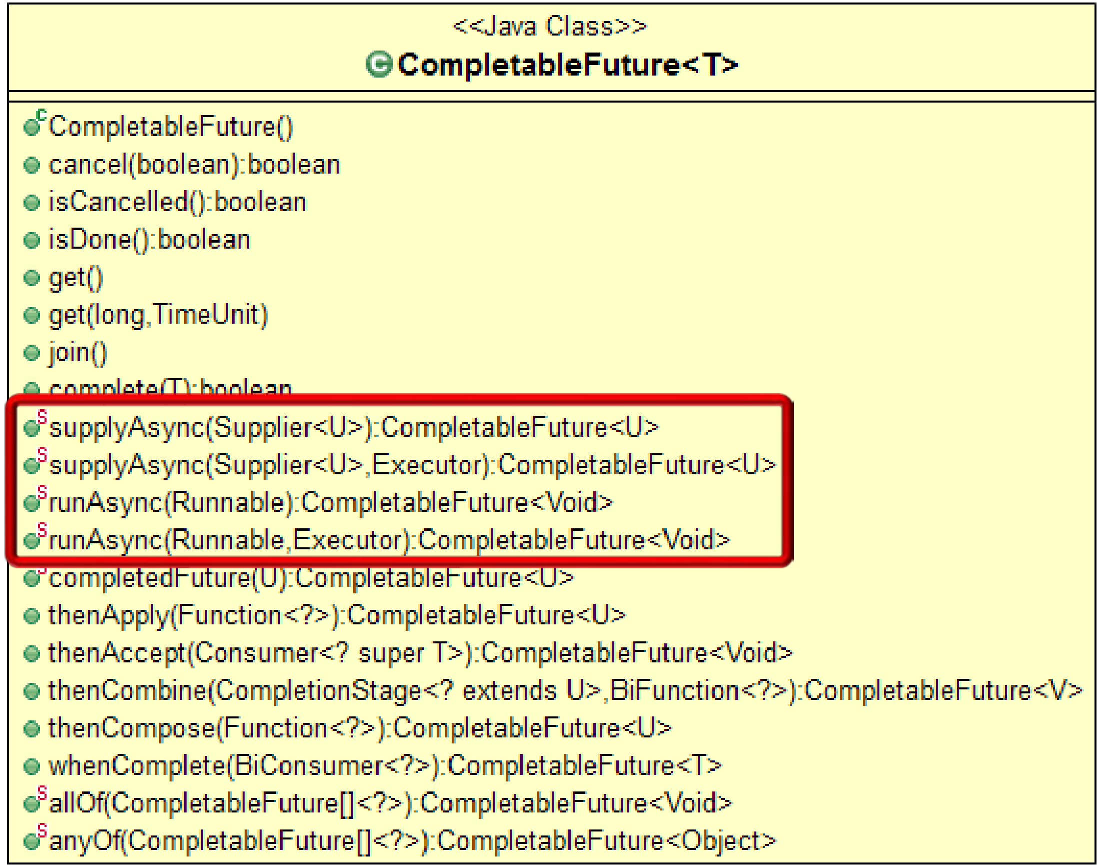
Overview of Completable Futures

- Other completable future features are more advanced
  - Factory methods
    - Initiate async two-way or one-way functionality



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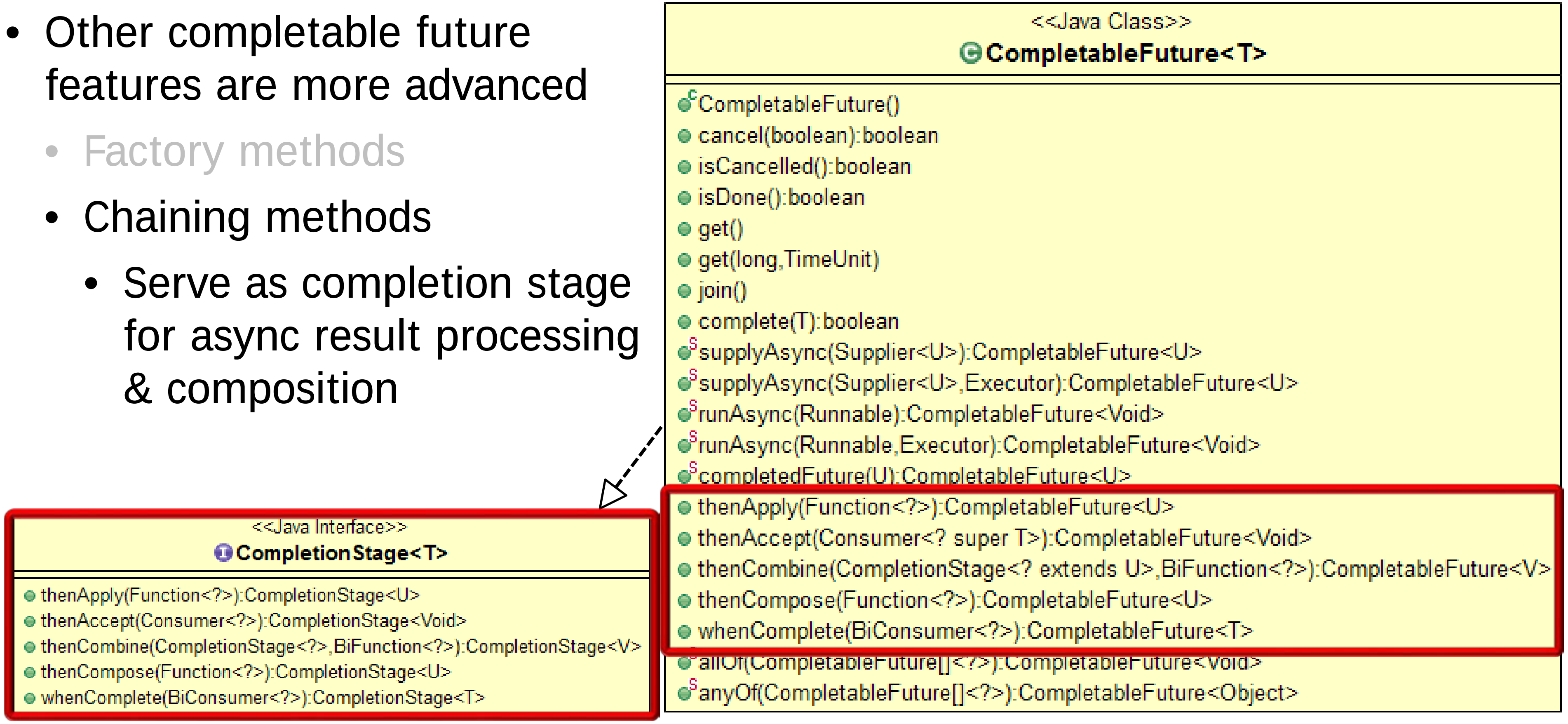
Overview of Completable Futures

- Other completable future features are more advanced
  - Factory methods
  - Chaining methods
    - Serve as completion stage for async result processing & composition



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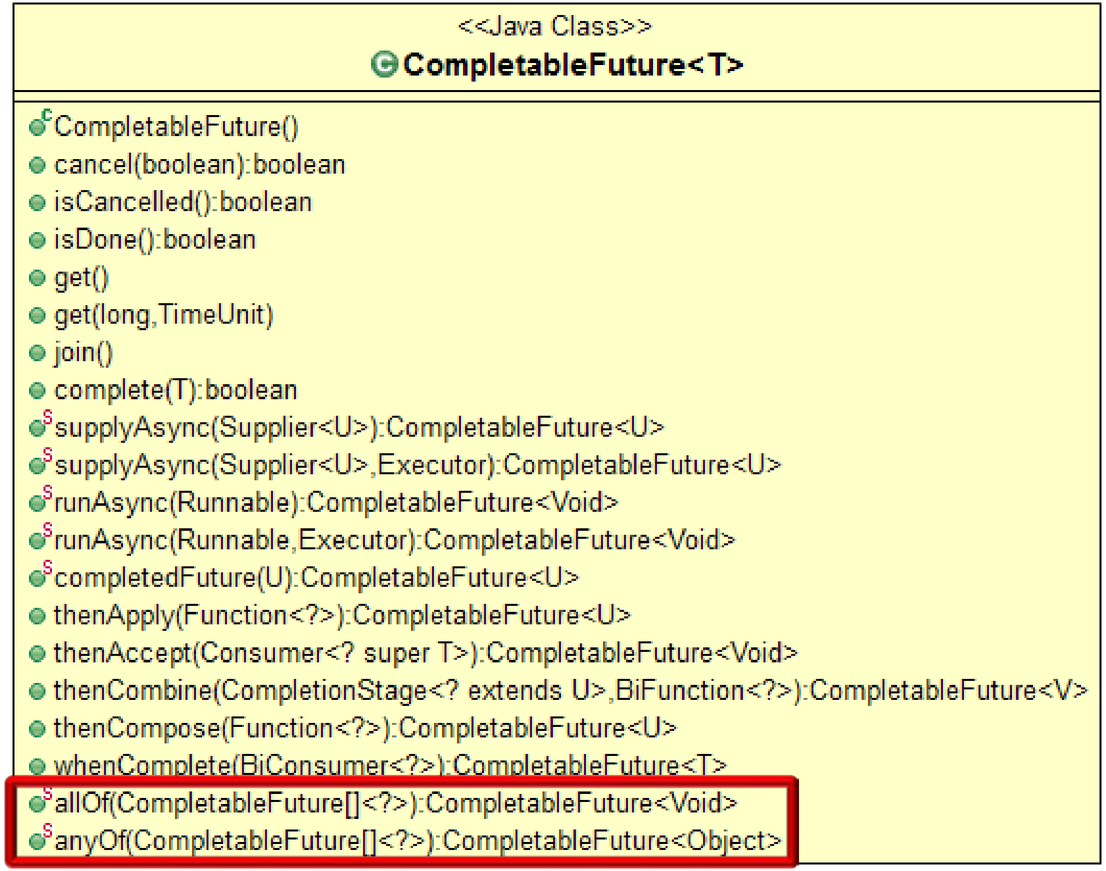
See docs.oracle.com/javase/8/docs/api/java/util/concurrent/CompletionStage.html

Overview of Completable Futures

- Other completable future features are more advanced
  - Factory methods
  - Chaining methods
  - “Arbitrary-arity” methods that process futures in bulk
    - Combine multiple futures into a single future



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See en.wikipedia.org/wiki/Arity

End of Overview of Java 8 Completable Futures (Part 1)