Advanced Java CompletableFuture Features: Single Stage Completion Methods

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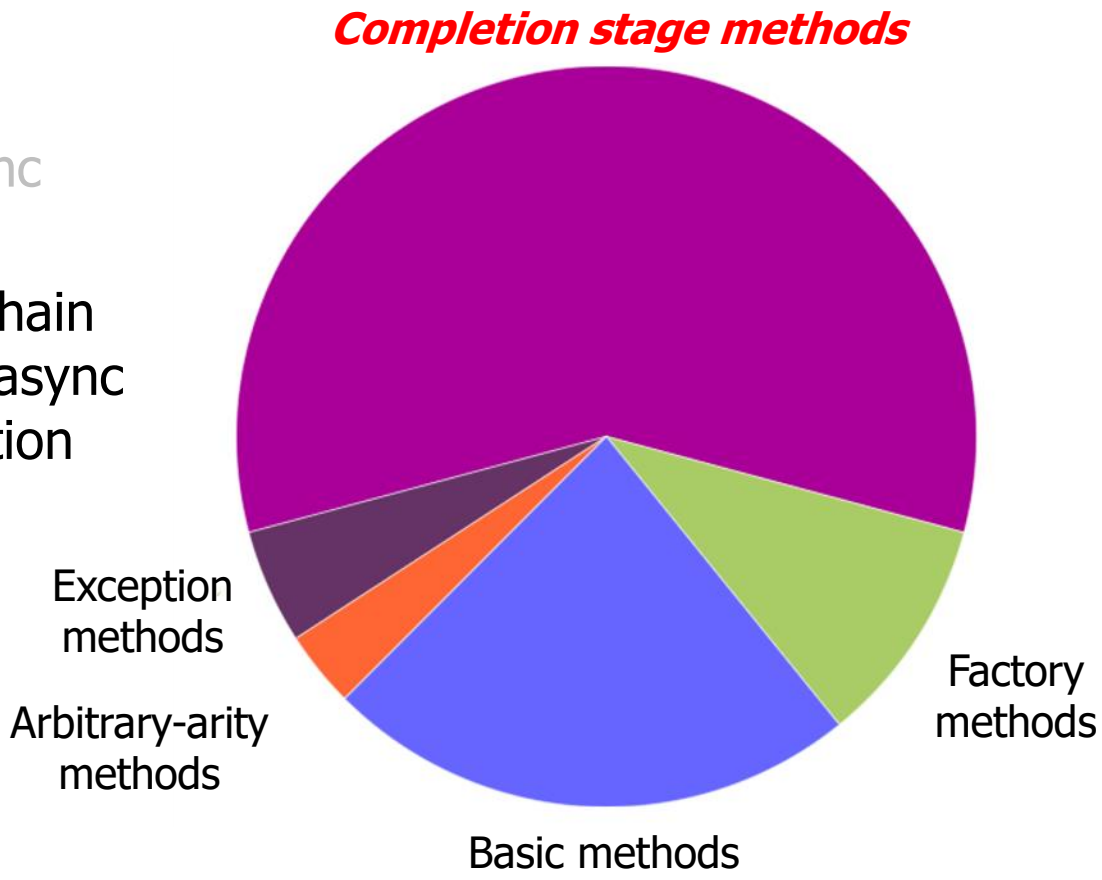
Learning Objectives in this Part of the Lesson

- Understand advanced features of completable futures, e.g.
  - Factory methods initiate async computations
  - Completion stage methods chain together actions to perform async result processing & composition
    - Method grouping
    - Single stage methods



Methods Triggered by Completion of a Single Stage

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- Methods triggered by completion of a single previous stage
  - thenApply()

```
CompletableFuture<U> thenApply
   (Function<? super T,
                 ? extends U> fn)
{ ... }
```

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

Methods Triggered by Completion of a Single Stage

- Methods triggered by completion of a single previous stage
  - thenApply()
    - Applies a function action to the previous stage's result

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   (Function<? super T,
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See docs.oracle.com/javase/8/docs/api/java/util/function/Function.html

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- Methods triggered by completion of a single previous stage
  - thenApply()
    - Applies a function action to the previous stage's result
    - Returns a future containing the result of the action

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CompletableFuture<U> thenApply
   (Function<? super T,
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{ ... }
```

Methods Triggered by Completion of a Single Stage

- Methods triggered by completion of a single previous stage
  - thenApply()
    - Applies a function action to the previous stage's result
    - Returns a future containing the result of the action
    - Used for a quick *sync* action that returns a value rather than a future

```
BigFraction unreduced = BigFraction
   .valueOf(new BigInteger("..."),
            new BigInteger("..."),
            false); // Don't reduce!

Supplier<BigFraction> reduce = ()
   -> BigFraction.reduce(unreduced);

CompletableFuture
   .supplyAsync(reduce)
   .thenApply(BigFraction
              ::toMixedString)
   ...
```

e.g., toMixedString() returns a string value

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

Methods Triggered by Completion of a Single Stage

- Methods triggered by completion of a single previous stage
  - thenApply()
  - thenCompose()

```
CompletableFuture<U> thenCompose
   (Function<? super T,
                 ? extends
                 CompletionStage<U>> fn)
{ ... }
```

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

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   (Function<? super T,
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Methods Triggered by Completion of a Single Stage

- Methods triggered by completion of a single previous stage
  - thenApply()
  - thenCompose()
    - Applies a function action to the previous stage's result
    - Returns a future containing result of the action directly
      - *i.e., not* a nested future

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CompletableFuture<U> thenCompose
   (Function<? super T,
                 ? extends
                 CompletionStage<U>> fn)
{ ... }
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```
CompletableFuture<U> thenCompose
   (Function<? super T,
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                 CompletionStage<U>> fn)
{ ... }
```

thenCompose() is similar to flatMap() on a Stream or Optional

See dzone.com/articles/understanding-flatmap

Methods Triggered by Completion of a Single Stage

- Methods triggered by completion of a single previous stage
  - thenApply()
  - thenCompose()
    - Applies a function action to the previous stage's result
    - Returns a future containing result of the action directly
    - Used for a longer *async* action that returns a future

```
Function<BF,
         CompletableFuture<BF>>
  reduceAndMultiplyFractions =
    unreduced -> CompletableFuture
    .supplyAsync
      (() -> BF.reduce(unreduced))



    .thenCompose
      (reduced -> CompletableFuture
       .supplyAsync(() ->
        reduced.multiply(...)));
  ...
```

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

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```
Function<BF,
         CompletableFuture<BF>>
reduceAndMultiplyFractions =
  unreduced -> CompletableFuture
  .supplyAsync
    (() -> BF.reduce(unreduced))
```

This function reduces & multiplies big fractions

```
  .thenCompose
    (reduced -> CompletableFuture
     .supplyAsync(() ->
      reduced.multiply(...)));
...
```

See docs.oracle.com/javase/8/docs/api/java/util/function/Function.html

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```
Function<BF,
            CompletableFuture<BF>>
  reduceAndMultiplyFractions =
    unreduced -> CompletableFuture
    .supplyAsync
      (() -> BF.reduce(unreduced))
```

Reduce big fraction asynchronously & return a completable future

```
    .thenCompose
      (reduced -> CompletableFuture
       .supplyAsync(() ->
        reduced.multiply(...)));
  ...
```

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

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```
Function<BF,
          CompletableFuture<BF>>
  reduceAndMultiplyFractions =
    unreduced -> CompletableFuture
    .supplyAsync
      (() -> BF.reduce(unreduced))
```

```
    .thenCompose
      (reduced -> CompletableFuture
       .supplyAsync(() ->
        reduced.multiply(...)));
  ...
```

supplyAsync() returns a future, but thenCompose() "flattens" this future

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

Methods Triggered by Completion of a Single Stage

- Methods triggered by completion of a single previous stage
  - thenApply()
  - thenCompose()
    - Applies a function action to the previous stage's result
    - Returns a future containing result of the action directly
    - Used for a longer *async* action that returns a future
    - Avoids unwieldy nesting of futures à la thenApply()

Nesting is unwieldy!

```
Function<BF, CompletableFuture<
                CompletableFuture<BF>>>
  reduceAndMultiplyFractions =
    unreduced -> CompletableFuture
    .supplyAsync
      (() -> BF.reduce(unreduced))
```

```
    .thenApply
      (reduced -> CompletableFuture
       .supplyAsync(() ->
        reduced.multiply(...)));
  ...
```

Methods Triggered by Completion of a Single Stage

- Methods triggered by completion of a single previous stage
  - thenApply()
  - thenCompose()
    - Applies a function action to the previous stage's result
    - Returns a future containing result of the action directly
    - Used for a longer *async* action that returns a future
    - Avoids unwieldy nesting of futures à la thenApply()

Flattening is more concise!

```
Function<BF,
                CompletableFuture<BF>>
  reduceAndMultiplyFractions =
    unreduced -> CompletableFuture
    .supplyAsync
      (() -> BF.reduce(unreduced))

    .thenApplyAsync(reduced
        -> reduced.multiply(...)));
  ...
  ...
```

thenApplyAsync() can often replace thenCompose(supplyAsync()) nestings

Methods Triggered by Completion of a Single Stage

- Methods triggered by completion of a single previous stage
  - thenApply()
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    - Applies a function action to the previous stage's result
    - Returns a future containing result of the action directly
    - Used for a longer *async* action that returns a future
    - Avoids unwieldy nesting of futures à la thenApply()

```
CompletableFuture<Integer> countF =
  .CompletableFuture
     .supplyAsync
        (() ->
         longRunnerReturnsCF())

     .thenCompose
       (Function.identity())
  ...
```

supplyAsync() will return a CompletableFuture to a CompletableFuture here!!

Can be used to avoid calling join() when flattening nested completable futures

Methods Triggered by Completion of a Single Stage

- Methods triggered by completion of a single previous stage
  - thenApply()
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    - Applies a function action to the previous stage's result
    - Returns a future containing result of the action directly
    - Used for a longer *async* action that returns a future
    - Avoids unwieldy nesting of futures à la thenApply()

```
CompletableFuture<Integer> countF =
  .CompletableFuture
     .supplyAsync
        (() ->
         longRunnerReturnsCF())

     .thenCompose
       (Function.identity())
...
```

This idiom flattens the return value to "just" one CompletableFuture!

Can be used to avoid calling join() when flattening nested completable futures

Methods Triggered by Completion of a Single Stage

- Methods triggered by completion of a single previous stage
  - thenApply()
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    - Applies a function action to the previous stage's result
    - Returns a future containing result of the action directly
    - Used for a longer *async* action that returns a future
    - Avoids unwieldy nesting of futures à la thenApply()

```
CompletableFuture<Integer> countF =
  .CompletableFuture
     .supplyAsync
        (() ->
         longRunnerReturnsCF())

     .thenComposeAsync
       (this::longerBlockerReturnsCF)
...
```

Runs longBlockerReturnsCF() in a thread in the fork-join pool

thenComposeAsync() can be used to avoid calling supplyAsync() again in a chain

Methods Triggered by Completion of a Single Stage

- Methods triggered by completion of a single previous stage
  - thenApply()
  - thenCompose()
  - thenAccept()

```
CompletableFuture<Void>
  thenAccept
    (Consumer<? super T> action)
{ ... }
```

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

Methods Triggered by Completion of a Single Stage

- Methods triggered by completion of a single previous stage
  - thenApply()
  - thenCompose()
  - thenAccept()
    - Applies a consumer action to handle previous stage's result

```
CompletableFuture<Void>
  thenAccept
    (Consumer<? super T> action)
{ ... }
```

See docs.oracle.com/javase/8/docs/api/java/util/function/Consumer.html

Methods Triggered by Completion of a Single Stage

- Methods triggered by completion of a single previous stage
  - thenApply()
  - thenCompose()
  - thenAccept()
    - Applies a consumer action to handle previous stage's result

```
CompletableFuture<Void>
   thenAccept
      (Consumer<? super T> action)
{ ... }
```

This action behaves as a "callback" with a side-effect

See en.wikipedia.org/wiki/Callback_(computer_programming)

Methods Triggered by Completion of a Single Stage

- Methods triggered by completion of a single previous stage
  - thenApply()
  - thenCompose()
  - thenAccept()
    - Applies a consumer action to handle previous stage's result
    - Returns a future to Void

```
CompletableFuture<Void>
  thenAccept
    (Consumer<? super T> action)
{ ... }
```

See www.baeldung.com/java-void-type

Methods Triggered by Completion of a Single Stage

- Methods triggered by completion of a single previous stage
  - thenApply()
  - thenCompose()
  - thenAccept()
    - Applies a consumer action to handle previous stage's result
    - Returns a future to Void
    - Often used at the end of a chain of completion stages

```
BigFraction unreduced = BigFraction
   .valueOf(new BigInteger("..."),
            new BigInteger("..."),
            false); // Don't reduce!

Supplier<BigFraction> reduce = ()
   -> BigFraction.reduce(unreduced);

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

thenApply() returns a string future that thenAccept() prints when it completes

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

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- Methods triggered by completion of a single previous stage
  - thenApply()
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    - Applies a consumer action to handle previous stage's result
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Supplier<BigFraction> reduce = ()
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CompletableFuture
   .supplyAsync(reduce)
   .thenApply(BigFraction
              ::toMixedString)
   .thenAccept(System.out::println);
```

println() is a callback that has a side-effect (i.e., printing the mixed string)

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- Methods triggered by completion of a single previous stage
  - thenApply()
  - thenCompose()
  - thenAccept()
    - Applies a consumer action to handle previous stage's result
    - Returns a future to Void
    - Often used at the end of a chain of completion stages
    - May lead to "callback hell!"

See dzone.com/articles/callback-hell

End of Advanced Java CompletableFuture Features: Single Stage Completion Methods