Advanced Java CompletableFuture Features: Introducing Completion Stage Methods

Douglas C. Schmidt

d.schmidt@vanderbilt.edu

www.dre.vanderbilt.edu/~schmidt

Professor of Computer Science

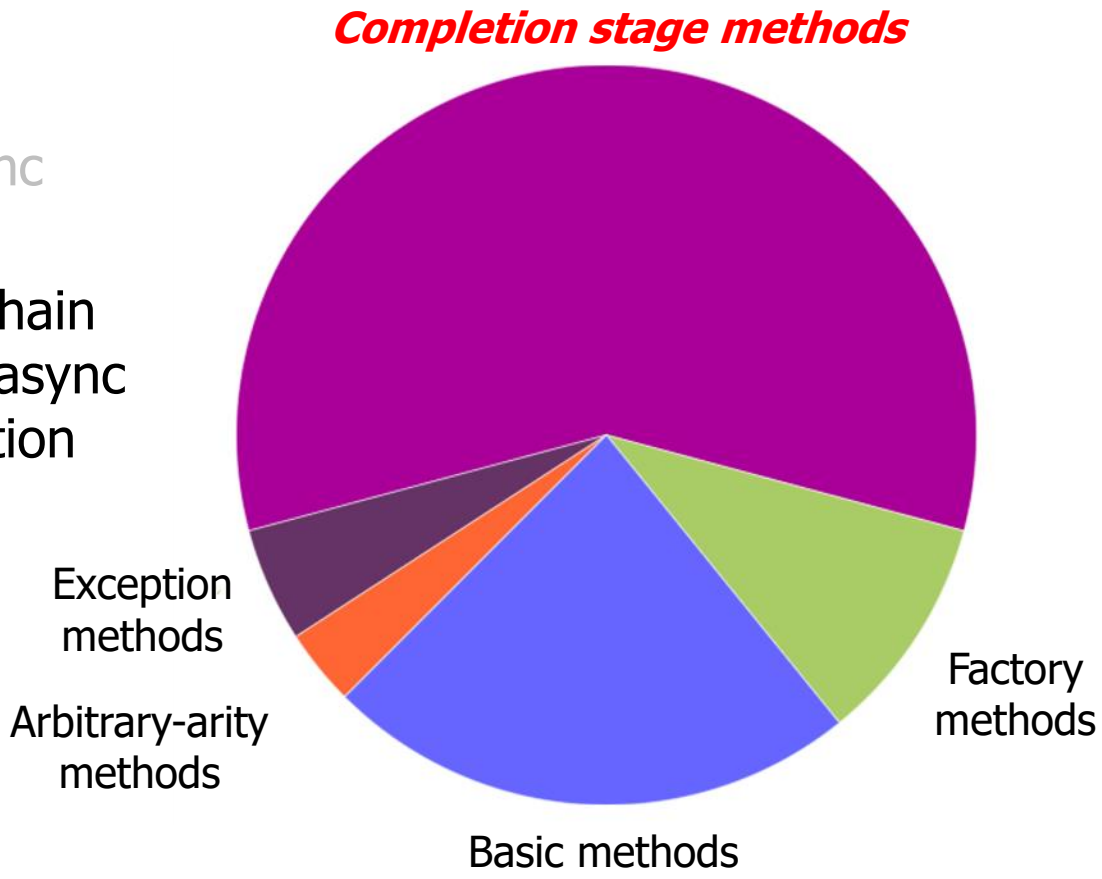
Institute for Software Integrated Systems

Vanderbilt University

Nashville, Tennessee, USA

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



Completion Stage Methods Chain Actions Together

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- A completable future can serve as a ”completion stage” for async result processing

Interface CompletionStage<T>

All Known Implementing Classes:

CompletableFuture

`public interface CompletionStage<T>`

A stage of a possibly asynchronous computation, that performs an action or computes a value when another CompletionStage completes. A stage completes upon termination of its computation, but this may in turn trigger other dependent stages. The functionality defined in this interface takes only a few basic forms, which expand out to a larger set of methods to capture a range of usage styles:

- The computation performed by a stage may be expressed as a Function, Consumer, or Runnable (using methods with names including *apply*, *accept*, or *run*, respectively) depending on whether it requires arguments and/or produces results. For example, `stage.thenApply(x -> square(x)).thenAccept(x -> System.out.print(x)).thenRun(() -> System.out.println())`. An additional form (*compose*) applies functions of stages themselves, rather than their results.
- One stage's execution may be triggered by completion of a single stage, or both of two stages, or either of two stages. Dependencies on a single stage are arranged using methods with prefix *then*. Those triggered by completion of *both* of two stages may *combine* their results or effects, using correspondingly named methods. Those triggered by *either* of two stages make no guarantees about which of the results or effects are used for the dependent stage's computation.

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

Completion Stage Methods Chain Actions Together

- A completable future can serve as a "completion stage" for async result processing
  - A dependent action runs on a completed async call result

```
BigFraction unreduced = BigFraction
   .valueOf(new BigInteger
                  ("8461225360066988 2"),
            new BigInteger
                  ("18802723413348219 6"),
            false); // Don't reduce!

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

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

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

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Create an unreduced big fraction variable

```
BigFraction unreduced = BigFraction
   .valueOf(new BigInteger
                  ("8461225536006698 82"),
            new BigInteger
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            false); // Don't reduce!

Supplier<BigFraction> reduce = () ->
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Create a supplier lambda variable that will reduce the big fraction

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

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This factory method will asynchronously reduce the big fraction supplier lambda

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```

thenApply()'s action is triggered when future from supplyAsync() completes

Completion Stage Methods Chain Actions Together

- A completable future can serve as a "completion stage" for async result processing
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  - Methods can be chained together "fluently"

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  BigFraction.reduce(unreduced);

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

thenAccept()'s action is triggered when future from thenApply() completes

See en.wikipedia.org/wiki/Fluent_interface

Completion Stage Methods Chain Actions Together

- A completable future can serve as a "completion stage" for async result processing
  - A dependent action runs on a completed async call result
  - Methods can be chained together "fluently"
    - Each method registers a lambda action to apply


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    - A lambda action is called only after previous stage completes successfully

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This is what is meant by "chaining"

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```

Action is "deferred" until previous stage completes & fork-join thread is available

Completion Stage Methods Chain Actions Together

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  - Try not to call join() or get() unless absolutely necessary

Servers may avoid blocking completely, whereas clients may need join() sparingly

Completion Stage Methods Chain Actions Together

- Use completion stages to avoid blocking a thread until the result *must* be obtained, e.g.
  - Try not to call join() or get() unless absolutely necessary
    - The goal is to improve responsiveness

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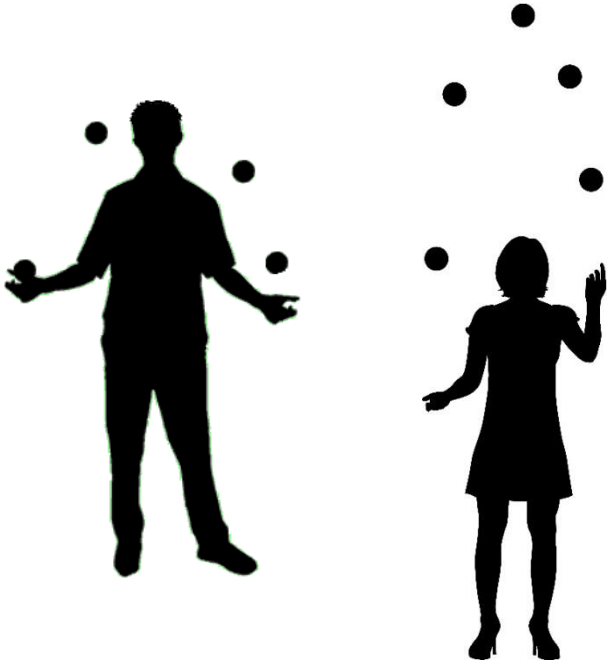

<<Java Class>>

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>
- whenComplete(BiConsumer<?>):CompletableFuture<T>
- allOf(CompletableFuture[]<?>):CompletableFuture<Void>
- anyOf(CompletableFuture[]<?>):CompletableFuture<Object>

Juggling is a good analogy for completion stages!

End of Advanced Java CompletableFuture Features: Introducing Completion Stage Methods