Understand Advanced Java CompletableFuture Features: Introducing Completion Stage Methods

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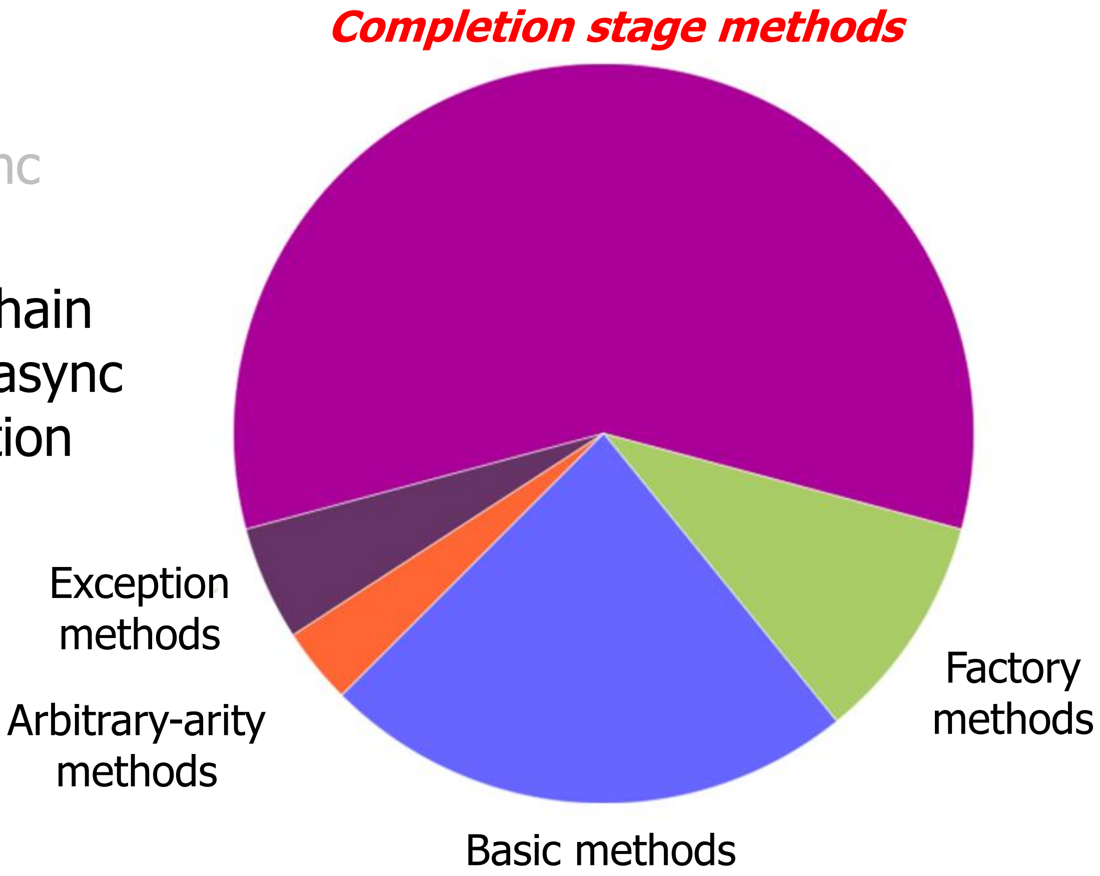
Learning Objectives in this Part of the Lesson

- 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



Completion Stage Methods Chain Actions Together

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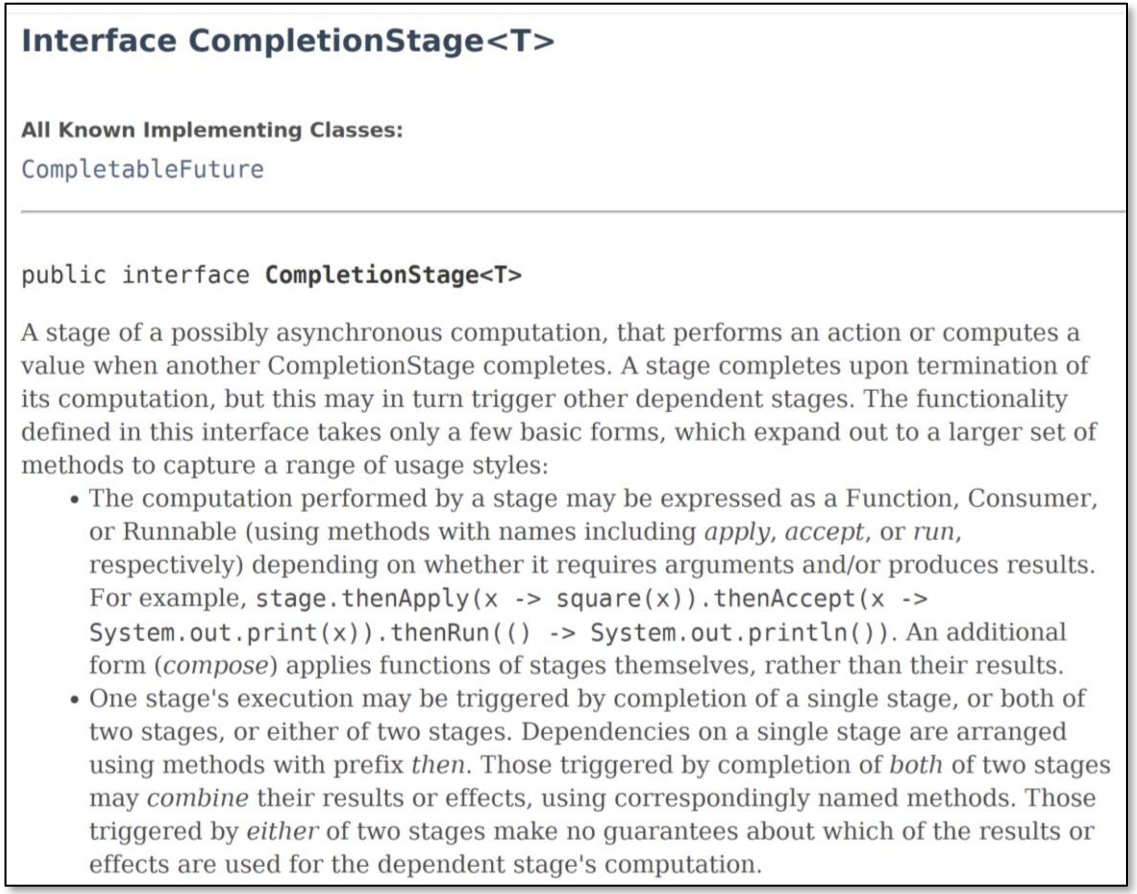
- A completable future can serve as a "completion stage" for async result processing



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
                ("846122553600669882"),
           new BigInteger
                ("188027234133482196"),
           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

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Create a supplier lambda variable that will reduce the big fraction

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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

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  - Methods can be chained together "fluently"

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

See en.wikipedia.org/wiki/Fluent_interface

Completion Stage Methods Chain Actions Together

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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

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  - A dependent action runs on a completed async call result
  - Methods can be chained together "fluently"
  - Fluent chaining enables async programming to look like sync programming

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Completion Stage Methods Chain Actions Together

- Use completion stages to avoid blocking the caller thread until the result *must* be obtained

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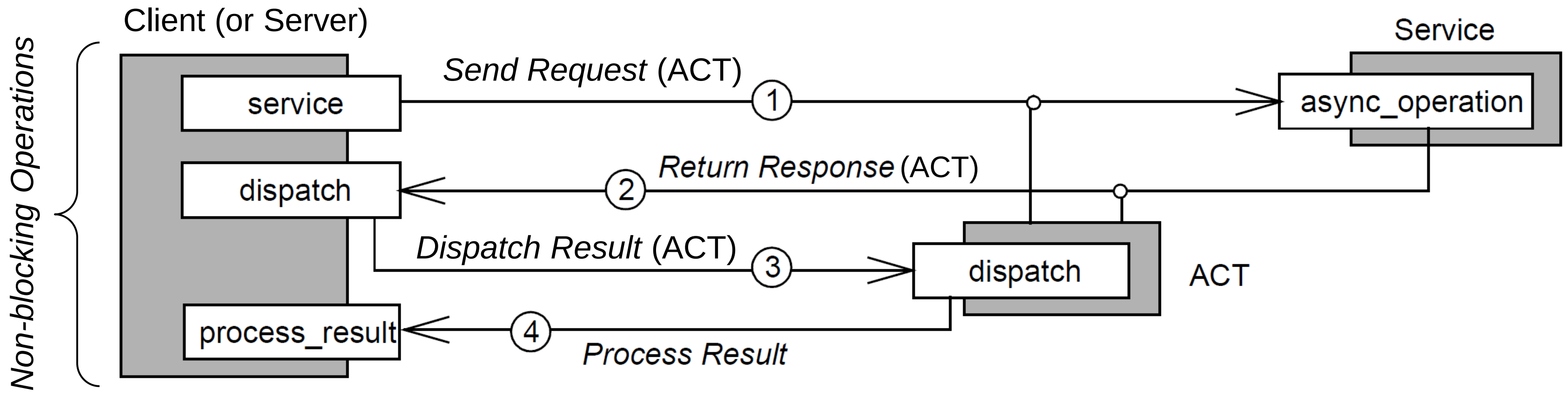
  - Avoid calling join() or get() unless absolutely necessary
    - Improves responsiveness by not blocking
    - Clients & servers that apply the *Asynchronous Completion Token* (ACT) pattern may avoid blocking completely



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

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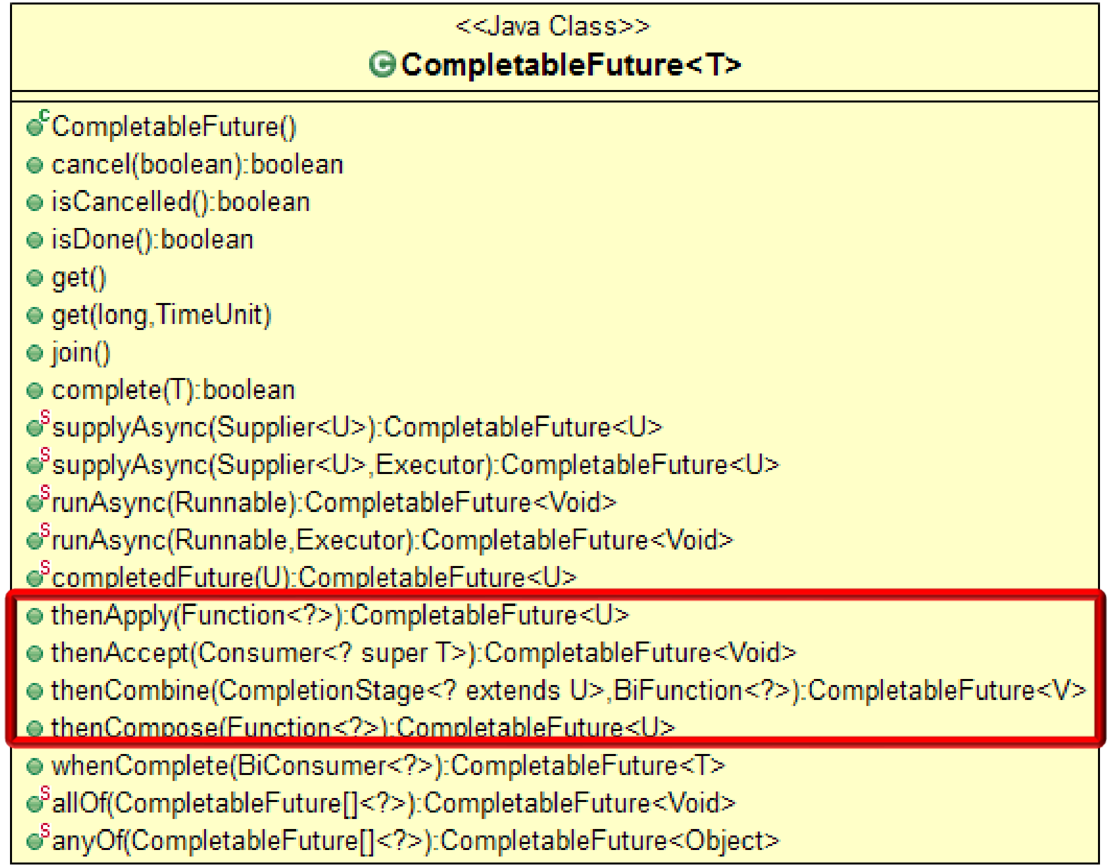

<<Java Class>>
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cancel(boolean):boolean
isCancelled():boolean
isDone():boolean
get()
get(long,TimeUnit)
join()
complete(T):boolean
supplyAsync(Supplier<U>):CompletableFuture<U>
supplyAsync(Supplier<U>,Executor):CompletableFuture<U>
runAsync(Runnable):CompletableFuture<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>
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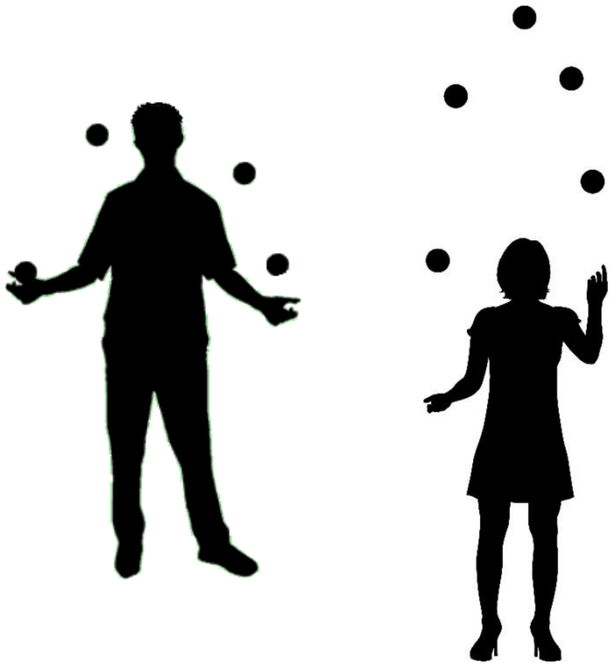

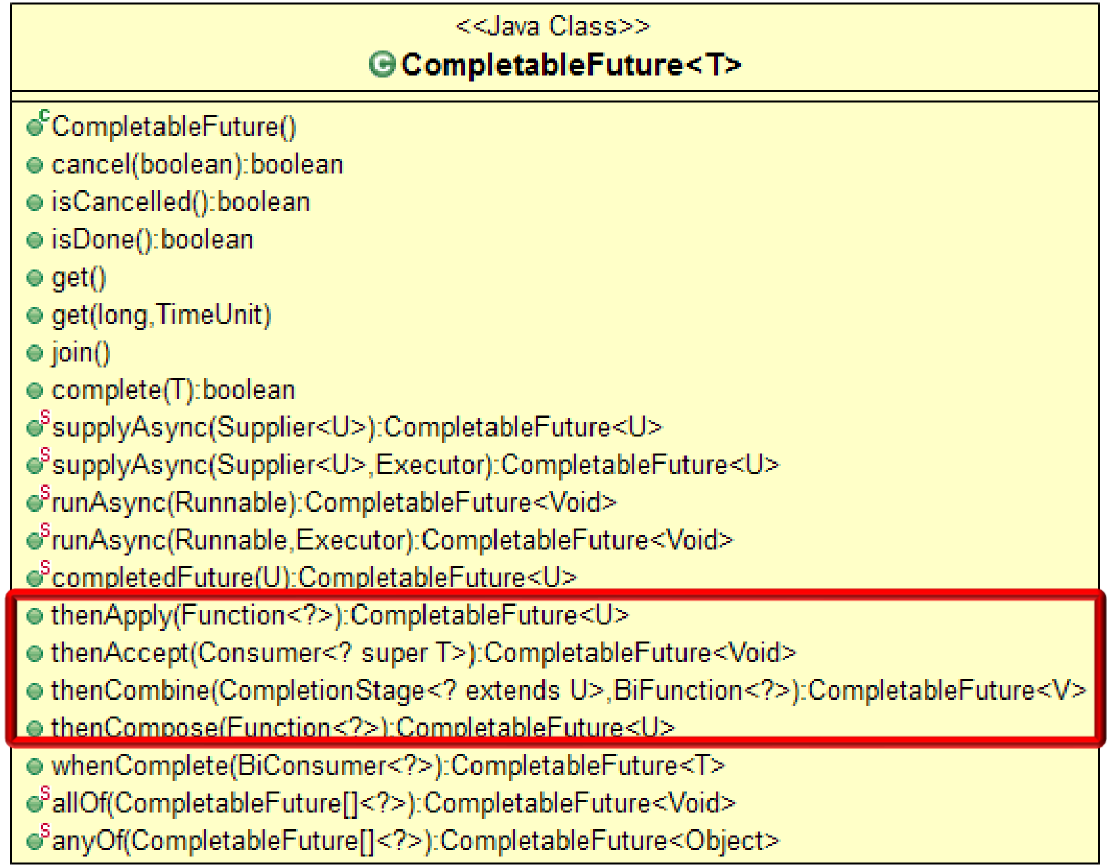

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Juggling is a good analogy for completion stages!

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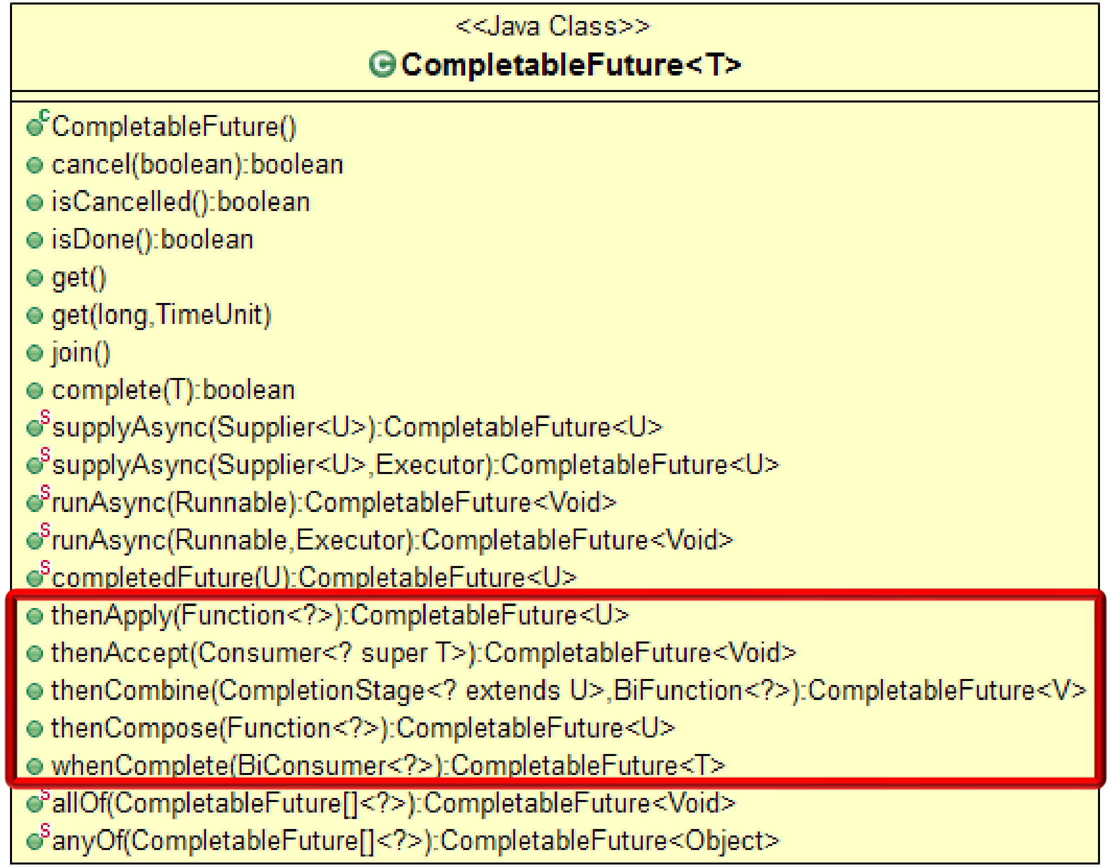
  - It only consumes resources when an action runs, which reduces system overhead



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See en.wikipedia.org/wiki/Start-stop_system

End of Understand Advanced Java CompletableFuture Features: Introducing Completion Stage Methods