Evaluating the Pros & Cons of Java Futures

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

- Motivate the need for Java futures by understanding the pros & cons of synchrony & asynchrony
- Know how Java futures provide the foundation for completable futures in Java
- Understand how to multiply BigFraction objects concurrently via Java futures
- Motivate the need for Java completable futures by evaluating the pros & cons with Java futures

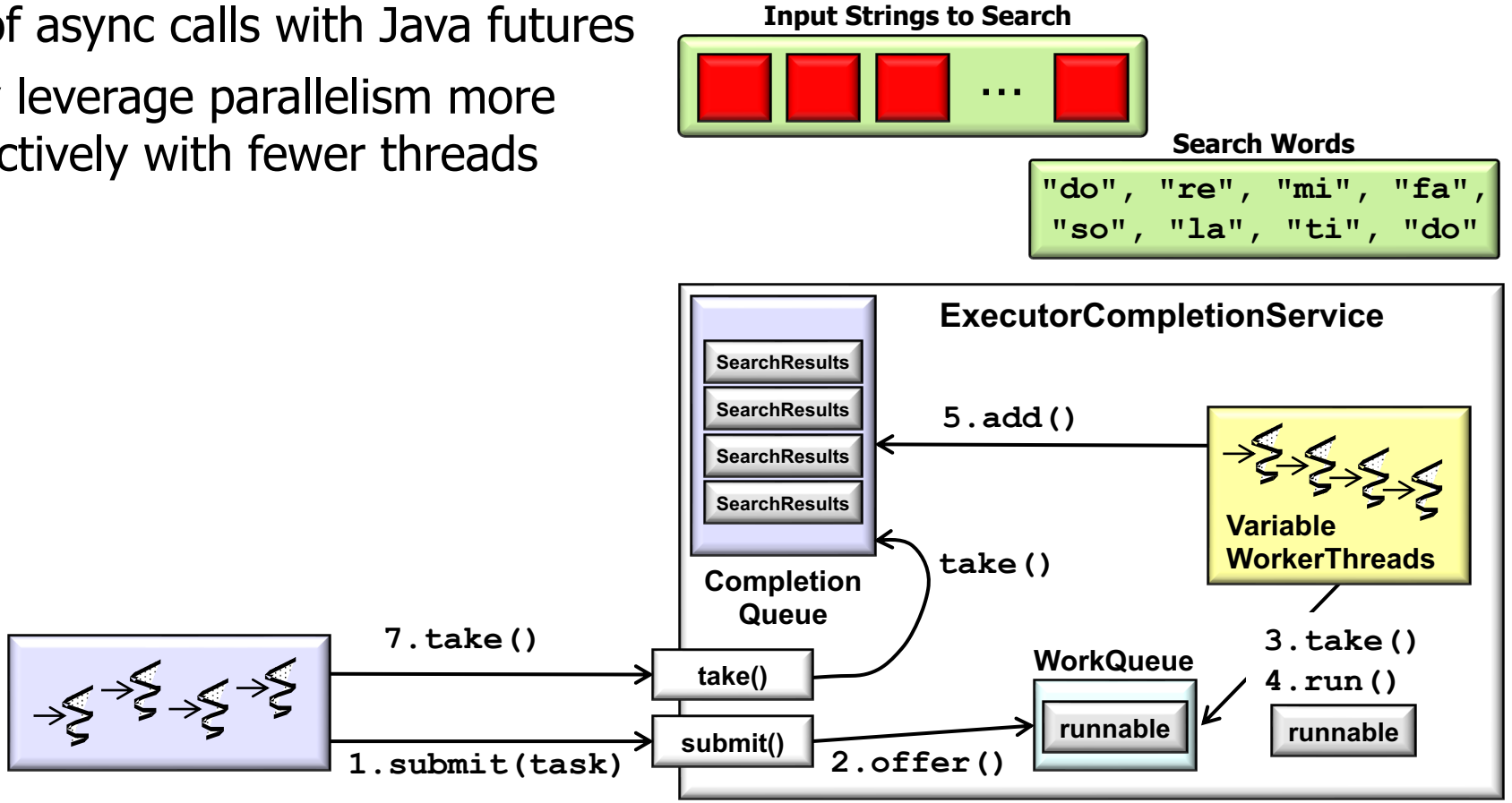
The Pros of Java Futures

The Pros of Java Futures

- Pros of async calls with Java futures

The Pros of Java Futures

- Pros of async calls with Java futures
  - May leverage parallelism more effectively with fewer threads

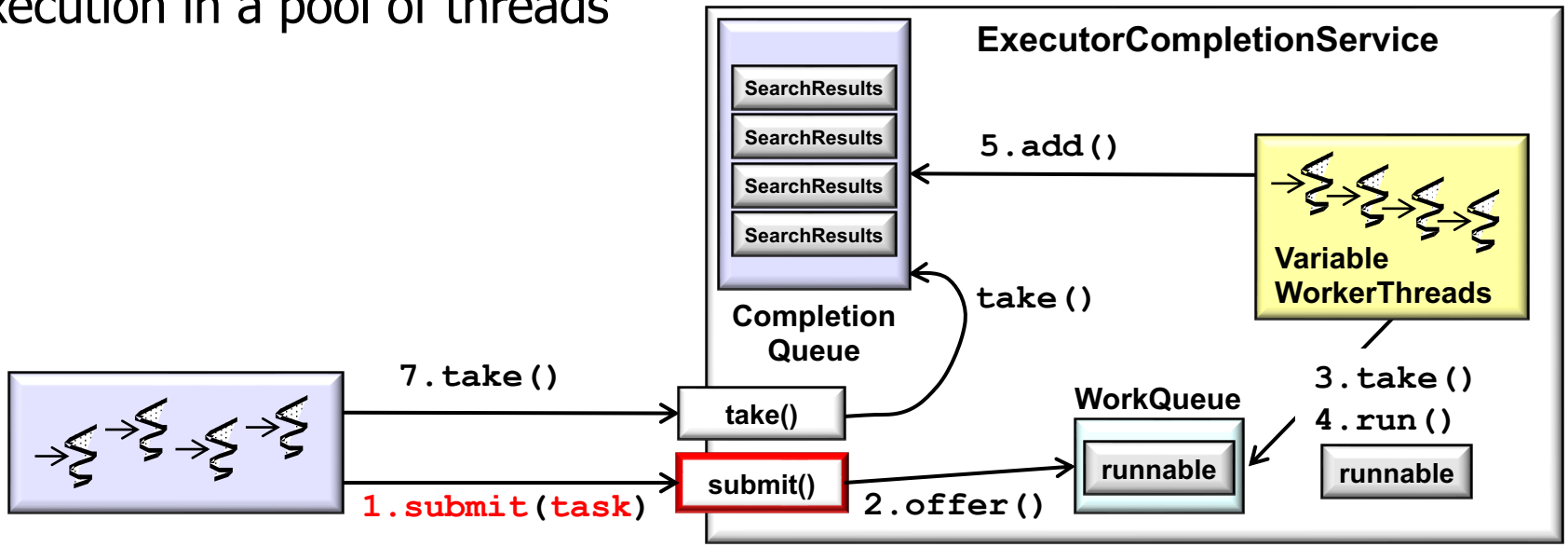


See github.com/douglascraigschmidt/LiveLessons/tree/master/SearchTaskGang

The Pros of Java Futures

- Pros of async calls with Java futures
  - May leverage parallelism more effectively with fewer threads, e.g.,
    - Queue async computations for execution in a pool of threads

```
mCompletionService
   .submit(() ->
              searchForWord(word,
                            input));
```



See docs.oracle.com/javase/8/docs/api/java/util/concurrent/ExecutorCompletionService.html#submit

The Pros of Java Futures

- Pros of async calls with Java futures
  - May leverage parallelism more effectively with fewer threads, e.g.,
    - Queue async computations for execution in a pool of threads
    - Automatically tune # of threads

```
mCompletionService
   .submit(() ->
              searchForWord(word,
                            input));
```

See docs.oracle.com/javase/8/docs/api/java/util/concurrent/Executors.html#newCachedThreadPool

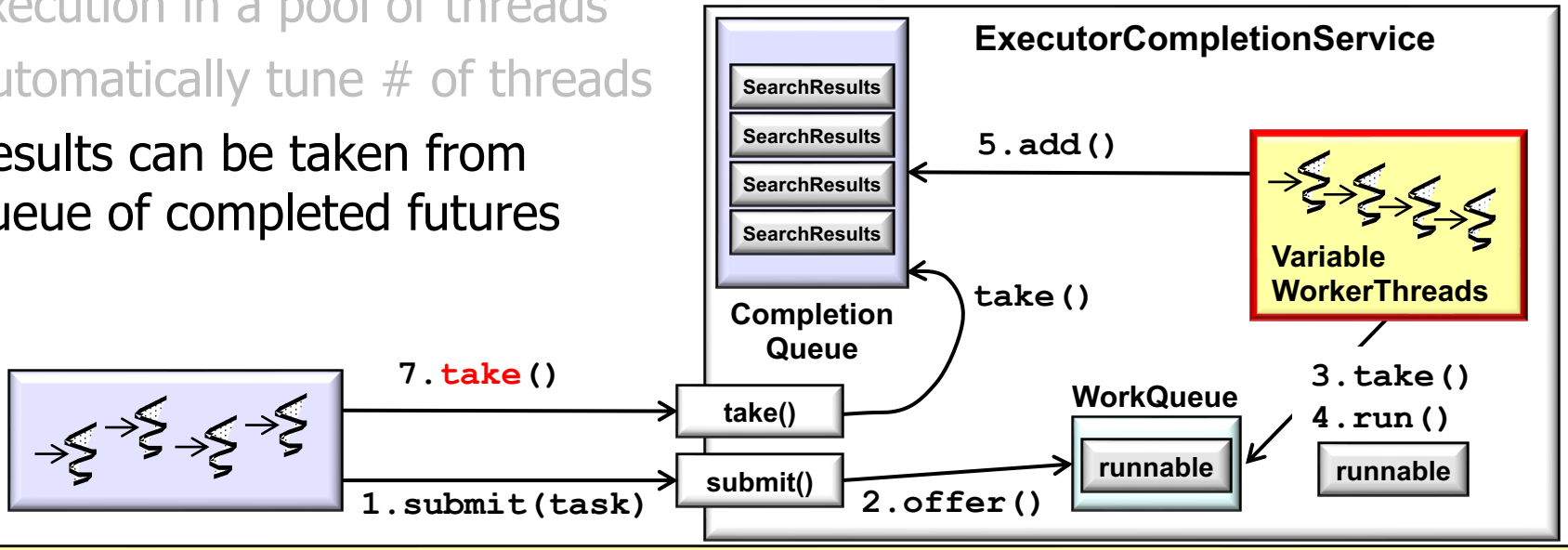
The Pros of Java Futures

- Pros of async calls with Java futures
  - May leverage parallelism more effectively with fewer threads, e.g.,
    - Queue async computations for execution in a pool of threads
    - Automatically tune # of threads
    - Results can be taken from queue of completed futures

```
Future<SearchResults> resultF =
    mCompletionService.take();
```

take() blocks, but get() doesn't

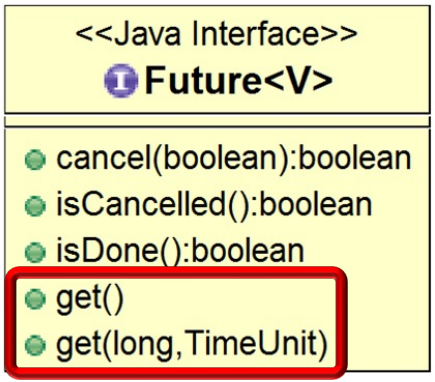
```
resultF.get().print()
```



See docs.oracle.com/javase/8/docs/api/java/util/concurrent/ExecutorCompletionService.html#take

The Pros of Java Futures

- Pros of async calls with Java futures
  - May leverage parallelism more effectively with fewer threads
  - Can block until the result of an async two-way task is available

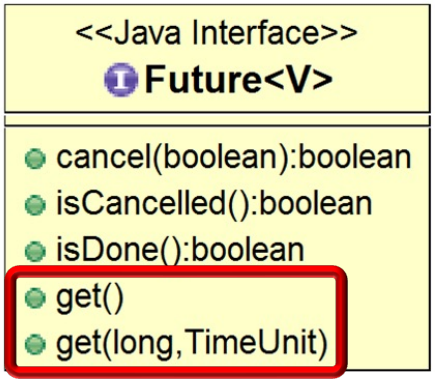



```
String f1 = "62675744/15668936";
String f2 = "609136/913704";

Future<BigFraction> f =
   commonPool().submit(() -> {
     BigFraction bf1 =
       new BigFraction(f1);
     BigFraction bf2 =
       new BigFraction(f2);
     return bf1.multiply(bf2);
   });
...
BigFraction result =
   f.get();
```

The Pros of Java Futures

- Pros of async calls with Java futures
  - May leverage parallelism more effectively with fewer threads
  - Can block until the result of an async two-way task is available
    - Can also poll or time-wait



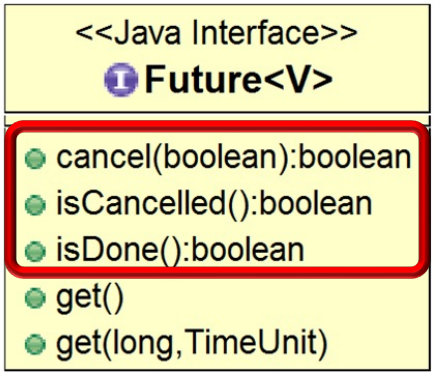

```
String f1 = "62675744/15668936";
String f2 = "609136/913704";

Future<BigFraction> f =
   commonPool().submit(() -> {
     BigFraction bf1 =
       new BigFraction(f1);
     BigFraction bf2 =
       new BigFraction(f2);
     return bf1.multiply(bf2);
   });
...
BigFraction result =
   f.get(n, MILLISECONDS);
```

May help to make an asynchronous program more responsive

The Pros of Java Futures

- Pros of async calls with Java futures
  - May leverage parallelism more effectively with fewer threads
  - Can block until the result of an async two-way task is available
  - Can be canceled & tested to see if a task is done or cancelled




```
String f1 = "62675744/15668936";
String f2 = "609136/913704";

Future<BigFraction> f =
   commonPool().submit(() -> {
     BigFraction bf1 =
       new BigFraction(f1);
     BigFraction bf2 =
       new BigFraction(f2);
     return bf1.multiply(bf2);
   });
...
if (!(f.isDone()
        || !f.isCancelled()))
   f.cancel();
```

May help to an asynchronous program more responsive & efficient wrt resource usage

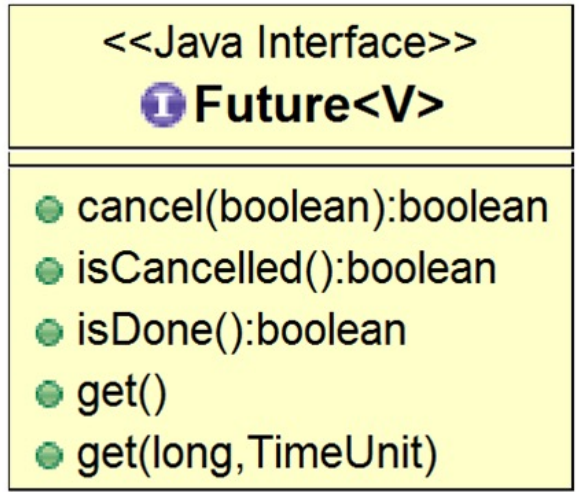
The Cons of Java Futures

The Cons of Java Futures

- Cons of async calls with Java futures

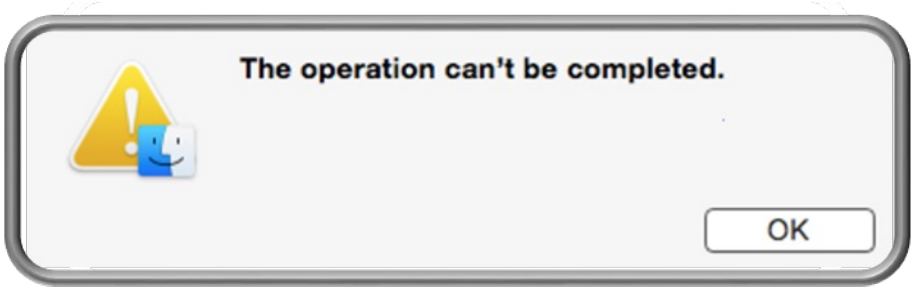
The Cons of Java Futures

- Cons of async calls with Java futures
  - Limited feature set



The Cons of Java Futures

- Cons of async calls with Java futures
  - Limited feature set
    - *Cannot* be completed explicitly
      - e.g., additional mechanisms like FutureTask are needed



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

The Cons of Java Futures

- Cons of async calls with Java futures
  - Limited feature set
    - *Cannot* be completed explicitly
    - *Cannot* be chained fluently
      - i.e., dependent actions can't be triggered to handle results of async processing

See en.wikipedia.org/wiki/Fluent_interface

The Cons of Java Futures

- Cons of async calls with Java futures
  - Limited feature set
    - *Cannot* be completed explicitly
    - *Cannot* be chained fluently
    - *Cannot* be triggered reactively
      - i.e., must (timed-)wait or poll


```
String f1 = "62675744/15668936";
String f2 = "609136/913704";

Future<BigFraction> f =
   commonPool().submit(() -> {
     BigFraction bf1 =
       new BigFraction(f1);
     BigFraction bf2 =
       new BigFraction(f2);
     return bf1.multiply(bf2);
   });
...
BigFraction result = f.get();
   // f.get(10, MILLISECONDS);
   // f.get(0, 0);
```

The Cons of Java Futures

- Cons of async calls with Java futures
  - Limited feature set
    - *Cannot* be completed explicitly
    - *Cannot* be chained fluently
    - *Cannot* be triggered reactively
      - i.e., must (timed-)wait or poll

Nearly always the wrong thing to do!!

```
String f1 = "62675744/15668936";
String f2 = "609136/913704";

Future<BigFraction> f =
   commonPool().submit(() -> {
     BigFraction bf1 =
       new BigFraction(f1);
     BigFraction bf2 =
       new BigFraction(f2);
     return bf1.multiply(bf2);
   });
...
BigFraction result = f.get();
   // f.get(10, MILLISECONDS);
   // f.get(0, 0);
```

See crondev.blog/2017/01/23/timeouts-with-java-8-completablefuture-youre-probably-doing-it-wrong

The Cons of Java Futures

- Cons of async calls with Java futures
  - Limited feature set
    - *Cannot* be completed explicitly
    - *Cannot* be chained fluently
    - *Cannot* be triggered reactively
    - *Cannot* be treated efficiently as a *collection* of futures

```
Future<BigFraction> future1 =
    commonPool().submit(() -> {
        ... });

Future<BigFraction> future2 =
    commonPool().submit(() -> {
        ... });

...
future1.get();
future2.get();
```

Can't wait efficiently for the completion of whichever async computation finishes first

The Cons of Java Futures

- Cons of async calls with Java futures
  - Limited feature set
    - *Cannot* be completed explicitly
    - *Cannot* be chained fluently
    - *Cannot* be triggered reactively
    - *Cannot* be treated efficiently as a *collection* of futures

In general, it's awkward & inefficient to "compose" multiple futures

The Cons of Java Futures

- These limitations with Java futures motivate the need for the Java completable futures 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.

See lesson on "*Overcoming Limitations with Java Futures via Java Completable Futures*"

End of Evaluating the Pros & Cons of Java Futures