Visualizing Java Futures in Action

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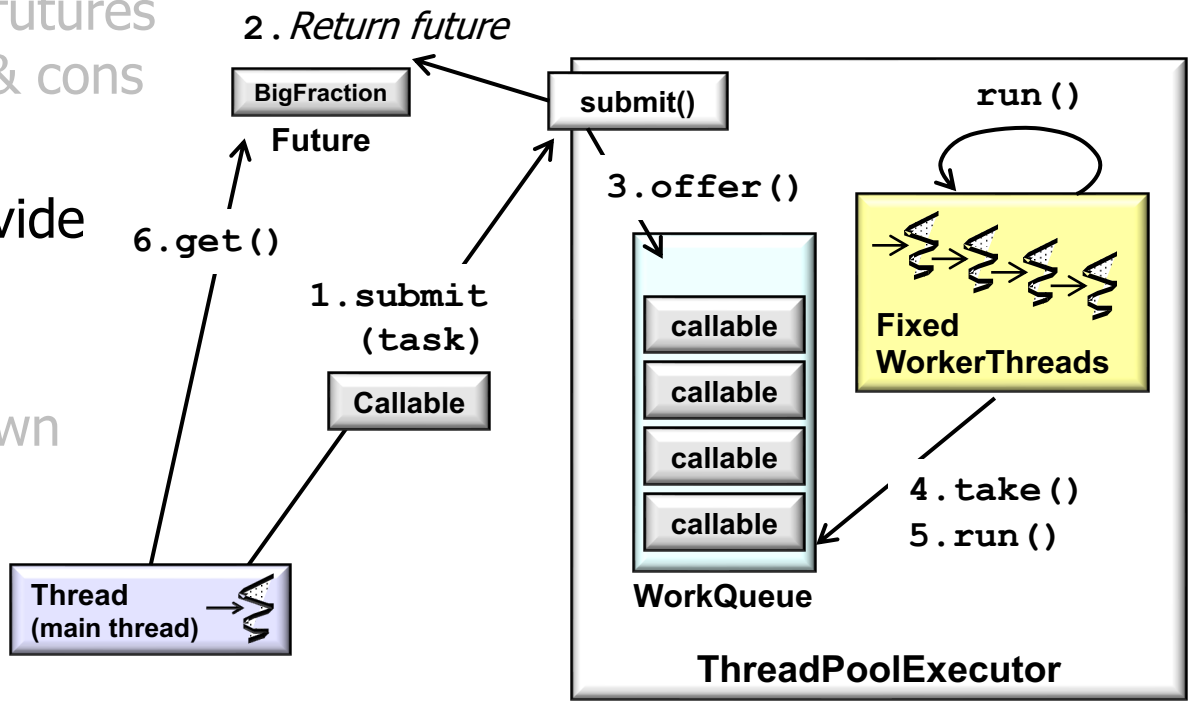
Learning Objectives in this Part of the Lesson

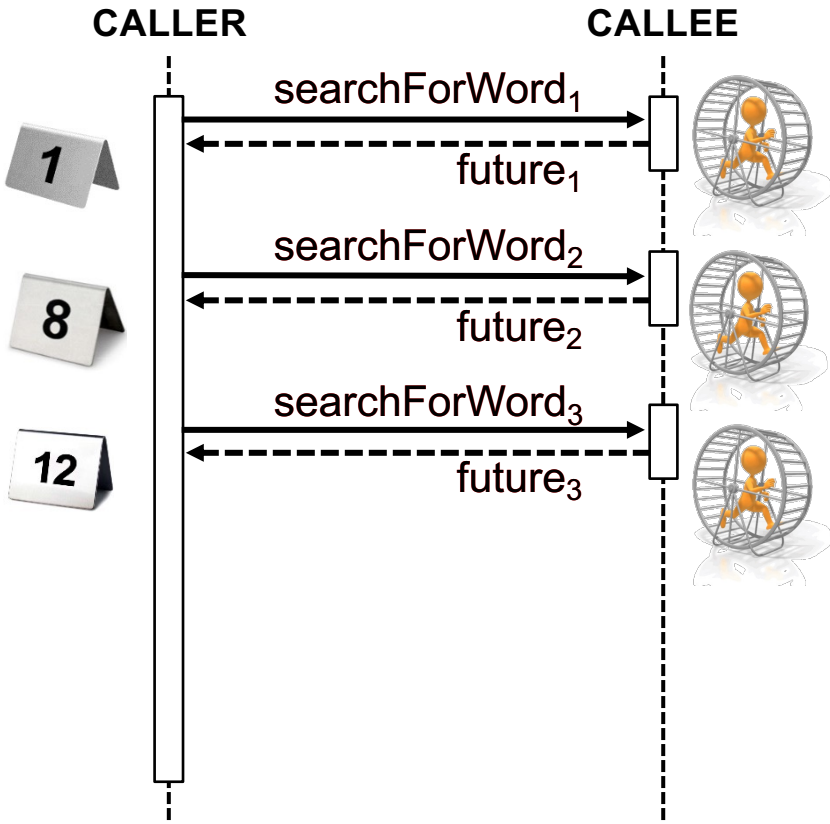
- Motivate the need for Java futures by understanding the pros & cons of synchrony & asynchrony
- Know how Java futures provide the foundation for Java completable futures
  - Understand a human known use of Java futures
  - Recognize the methods in the Future interface
  - Visualize Java futures in action



Visualizing Java Futures in Action

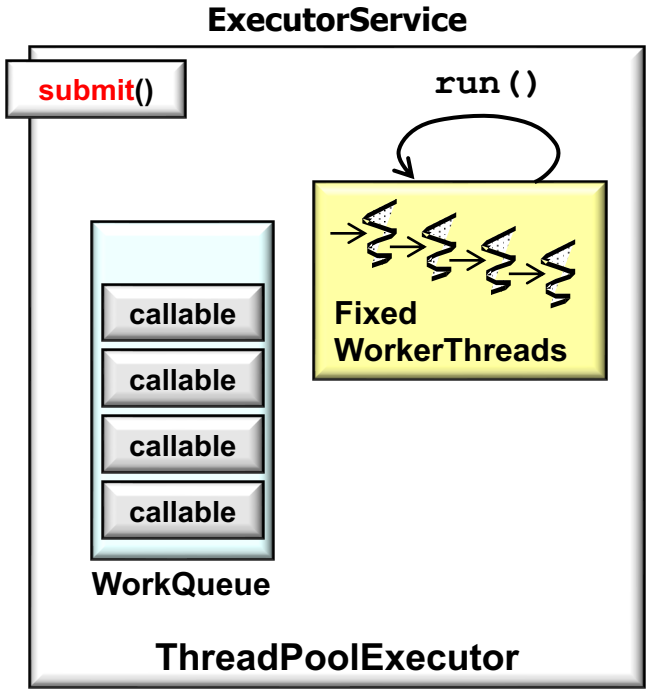
Visualizing Java Futures in Action

- An Java async call immediately returns a future & continues to run the computation in a background thread



Visualizing Java Futures in Action

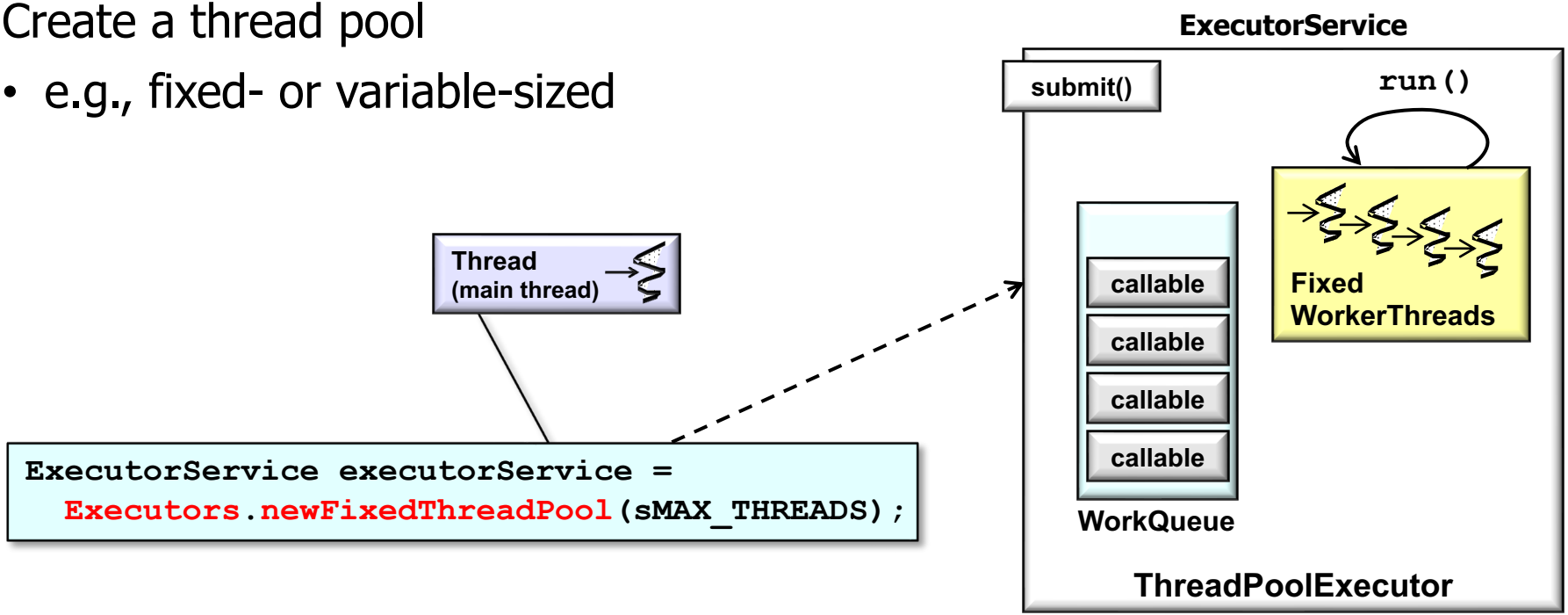
- ExecutorService.submit() can initiate an async call in Java



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

Visualizing Java Futures in Action

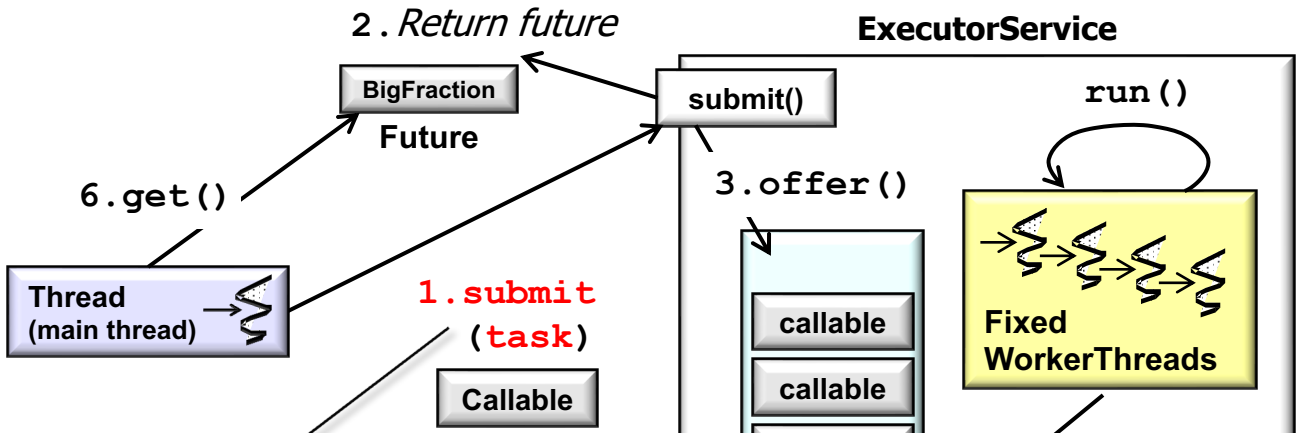
- ExecutorService.submit() can initiate an async call in Java
  - Create a thread pool
    - e.g., fixed- or variable-sized



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

Visualizing Java Futures in Action

- ExecutorService.submit() can initiate an async call in Java
  - Create a thread pool
  - Submit a task
    - e.g., a Callable



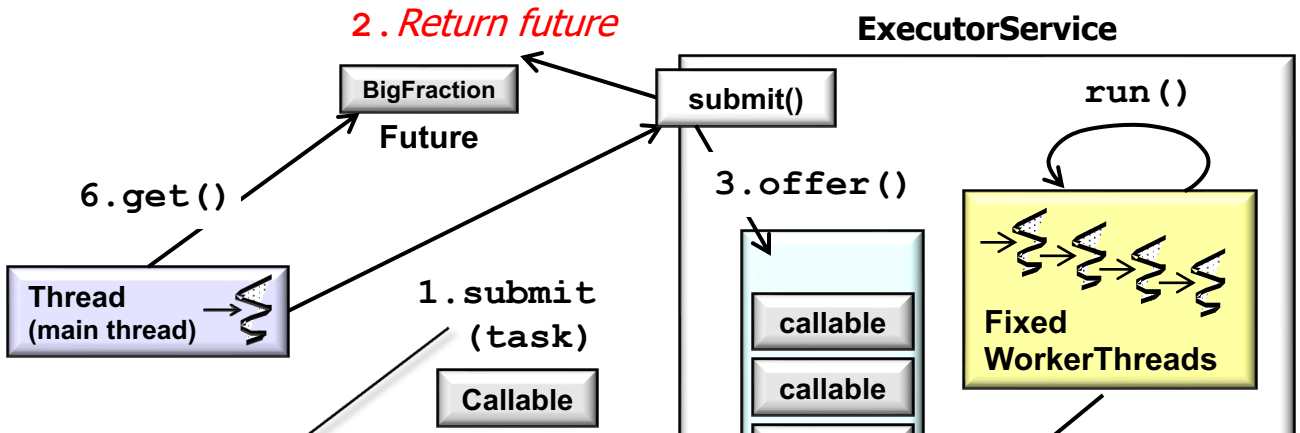

```
Callable<BigFraction> task = () -> {
  BigFraction bf1 = new BigFraction(f1);
  BigFraction bf2 = new BigFraction(f2);
  return bf1.multiply(bf2);
};

Future<BigFraction> future = executorService.submit(task);
```

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

Visualizing Java Futures in Action

- ExecutorService.submit() can initiate an async call in Java
  - Create a thread pool
  - Submit a task
  - Return a Future
    - e.g., implemented as a FutureTask

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Future<BigFraction> future = executorService.submit(task);
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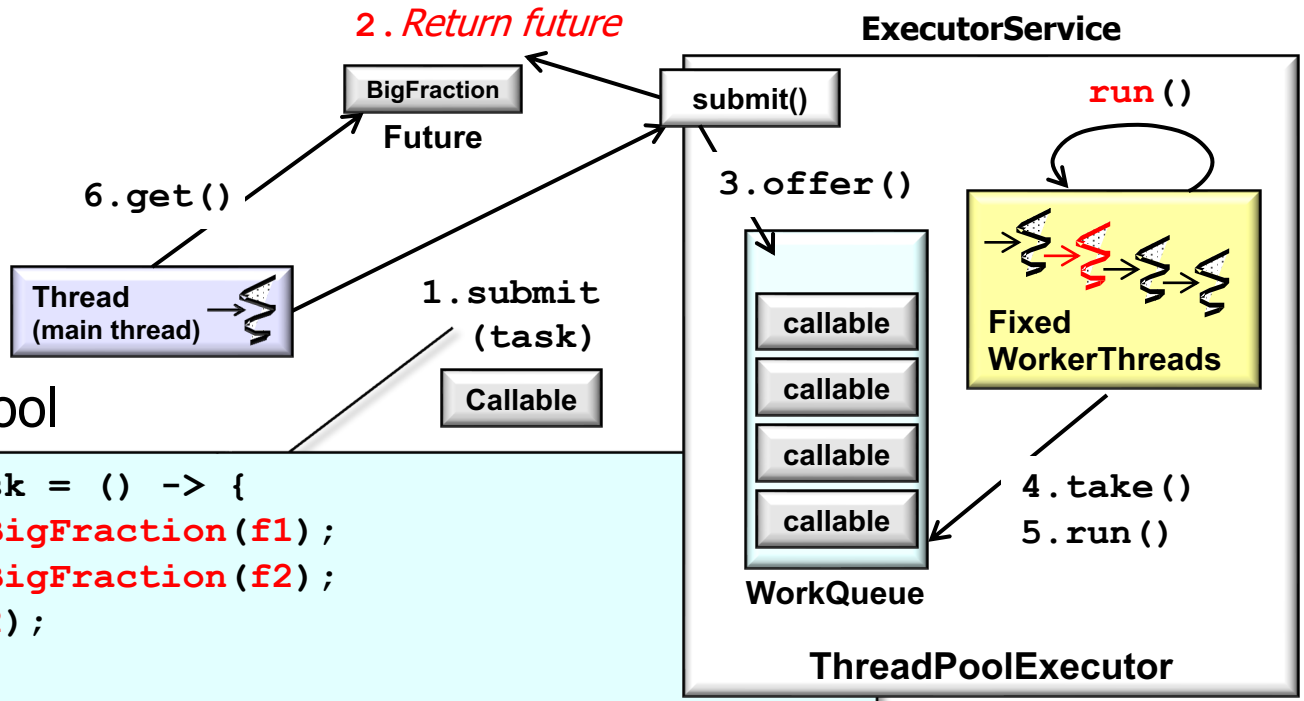
See docs.oracle.com/javase/8/docs/api/java/util/concurrent/FutureTask.html

Visualizing Java Futures in Action

- ExecutorService.submit() can initiate an async call in Java
  - Create a thread pool
  - Submit a task
  - Return a Future
  - Run computation asynchronously
    - e.g., in a thread pool

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Future<BigFraction> future = executorService.submit(task);
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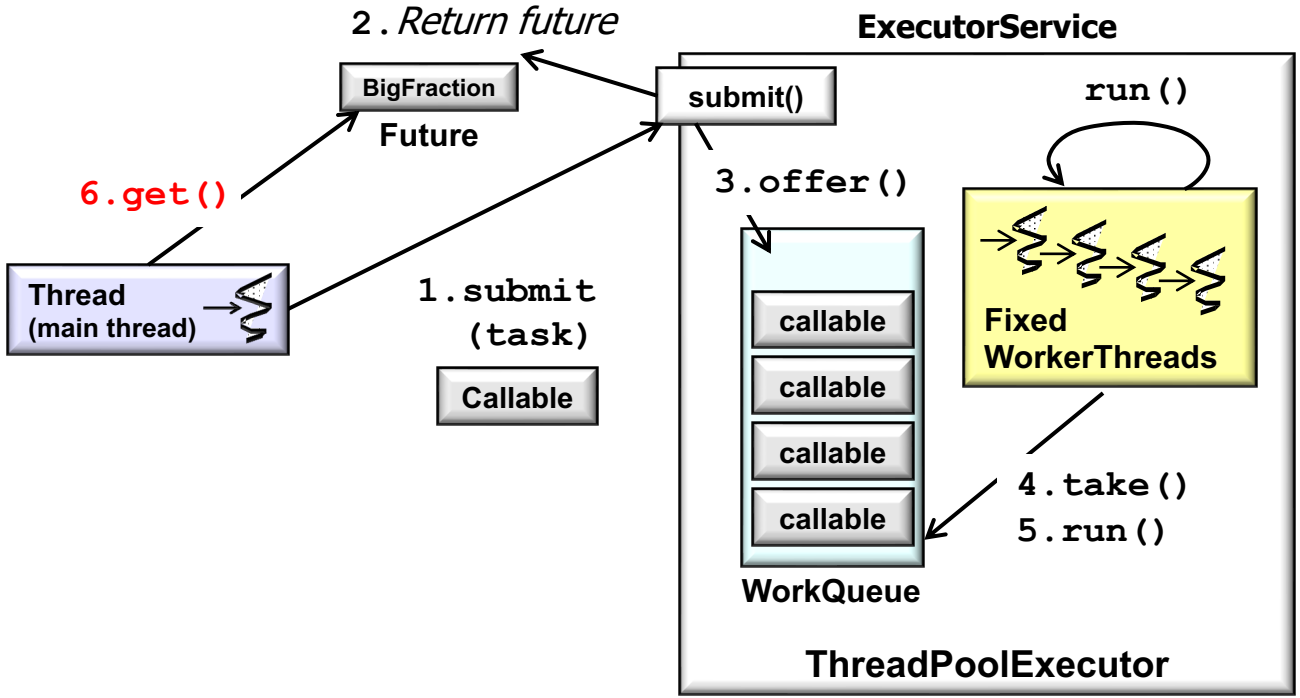
Visualizing Java Futures in Action

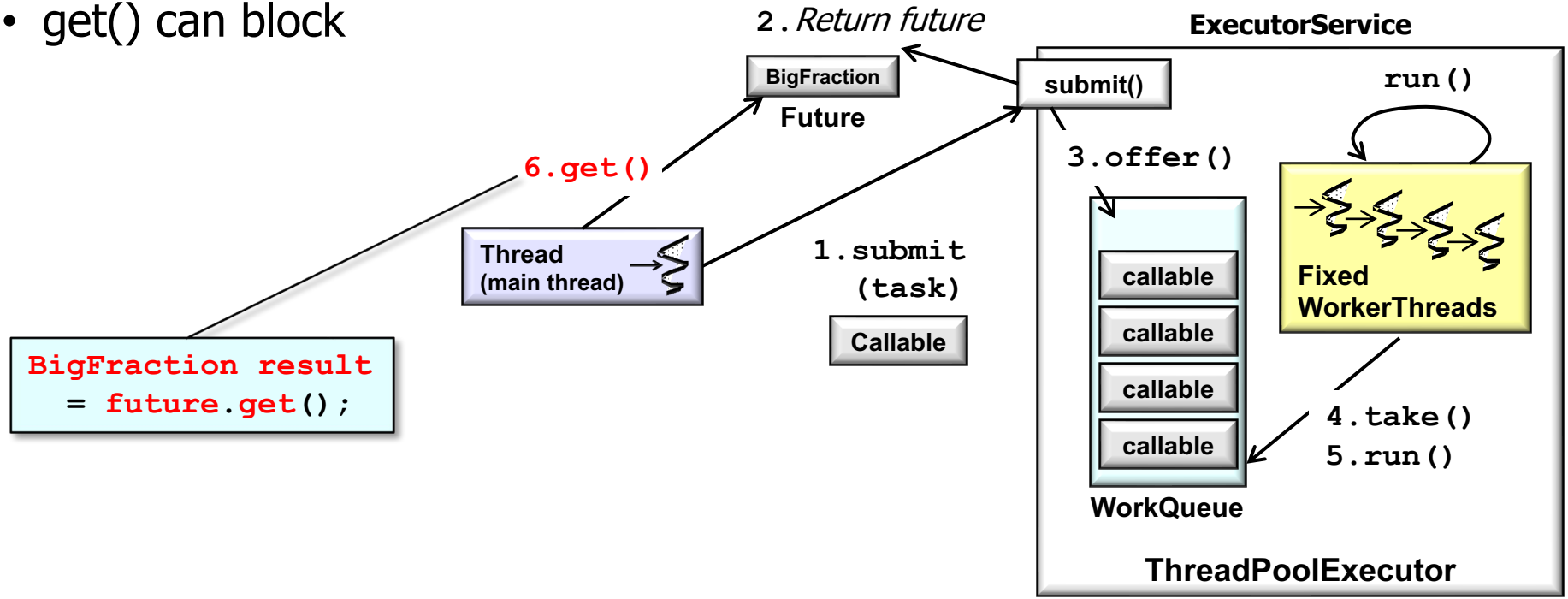
- When the async call completes the future is triggered & the result is available



See www.nurkiewicz.com/2013/02/javautilconcurrentfuture-basics.html

Visualizing Java Futures in Action

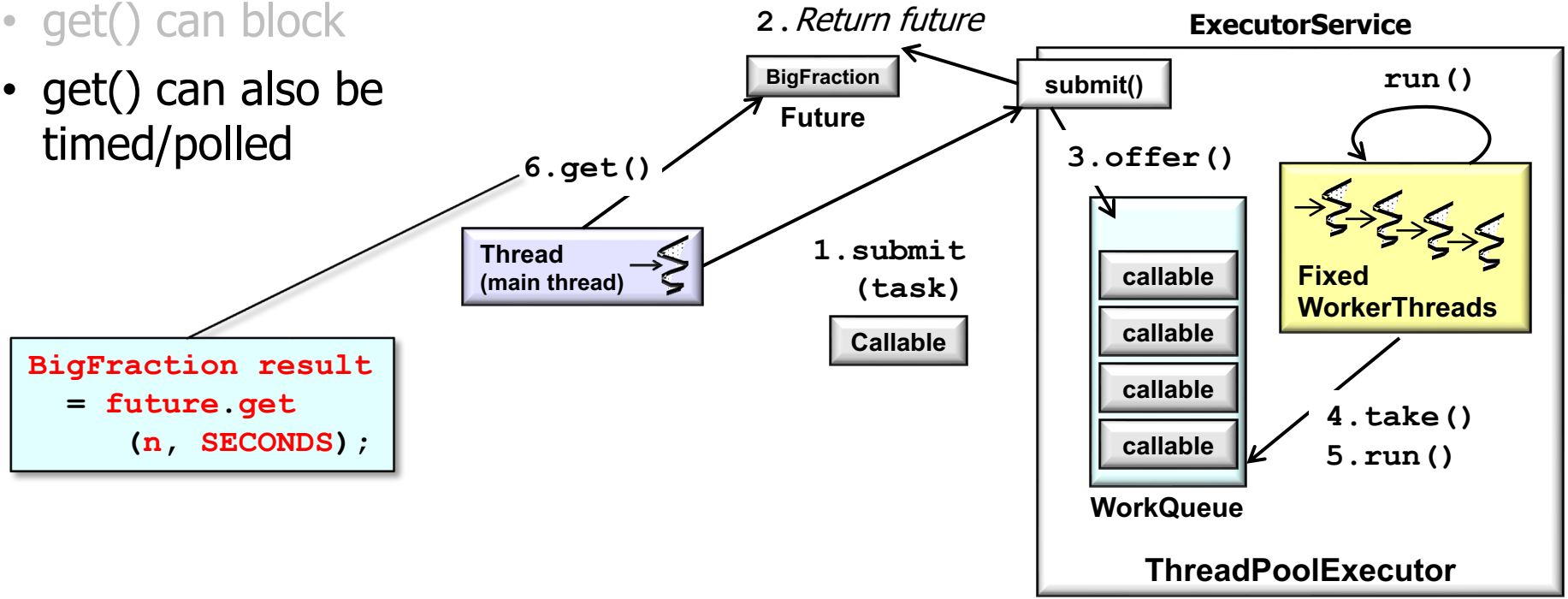
- When the async call completes the future is triggered & the result is available
  - get() can block



See docs.oracle.com/javase/8/docs/api/java/util/concurrent/Future.html#get

Visualizing Java Futures in Action

- When the async call completes the future is triggered & the result is available
  - get() can block
  - get() can also be timed/polled

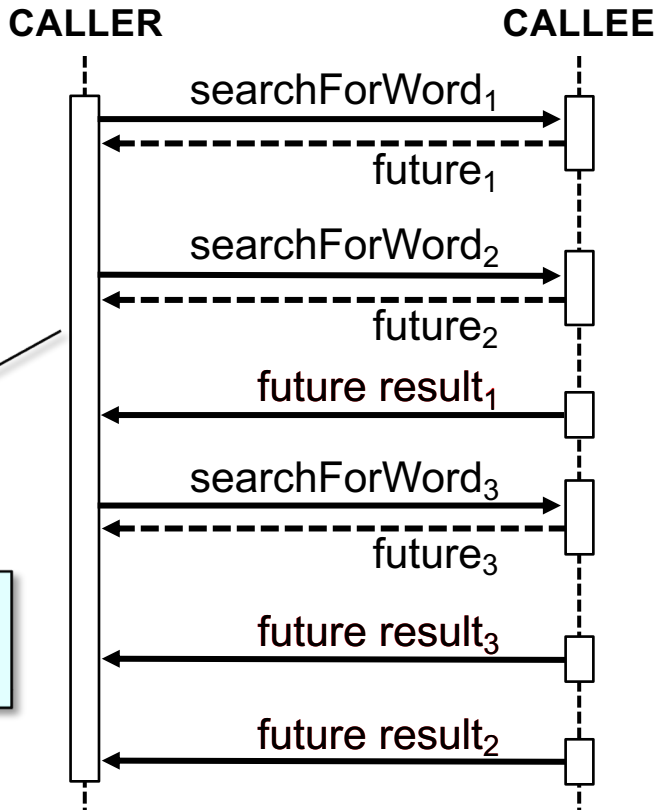


See docs.oracle.com/javase/8/docs/api/java/util/concurrent/Future.html#get

Visualizing Java Futures in Action

- When the async call completes the future is triggered & the result is available
  - get() can block
  - get() can also be timed/polled

Computations can complete in a different order than the async calls were made



End of Visualizing Java Futures in Action

Applying Java Futures in Practice

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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 Java completable futures
- Understand how to multiply BigFraction objects concurrently via Java futures

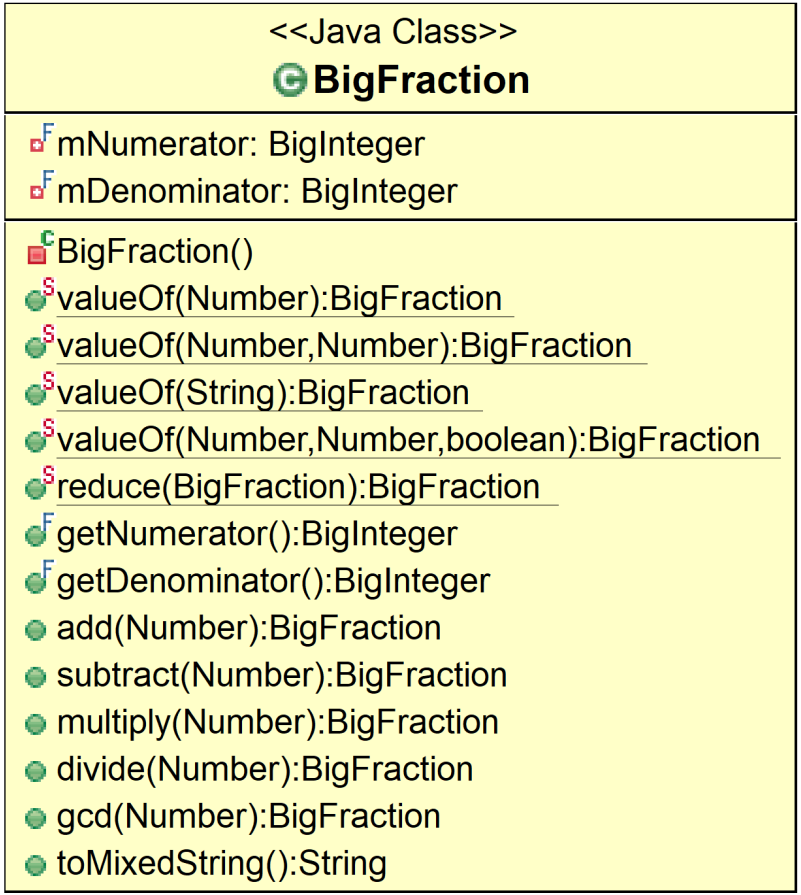
```
String f1 = "62675744/15668936";
String f2 = "609136/913704";

Callable<BigFraction> task =
   () -> {
   BigFraction bf1 =
     new BigFraction(f1);
   BigFraction bf2 =
     new BigFraction(f2);
   return bf1.multiply(bf2); };

Future<BigFraction> future =
   commonPool().submit(task);
...
BigFraction res = future.get();
```

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

Overview of the BigFraction Class

Overview of the BigFraction Class

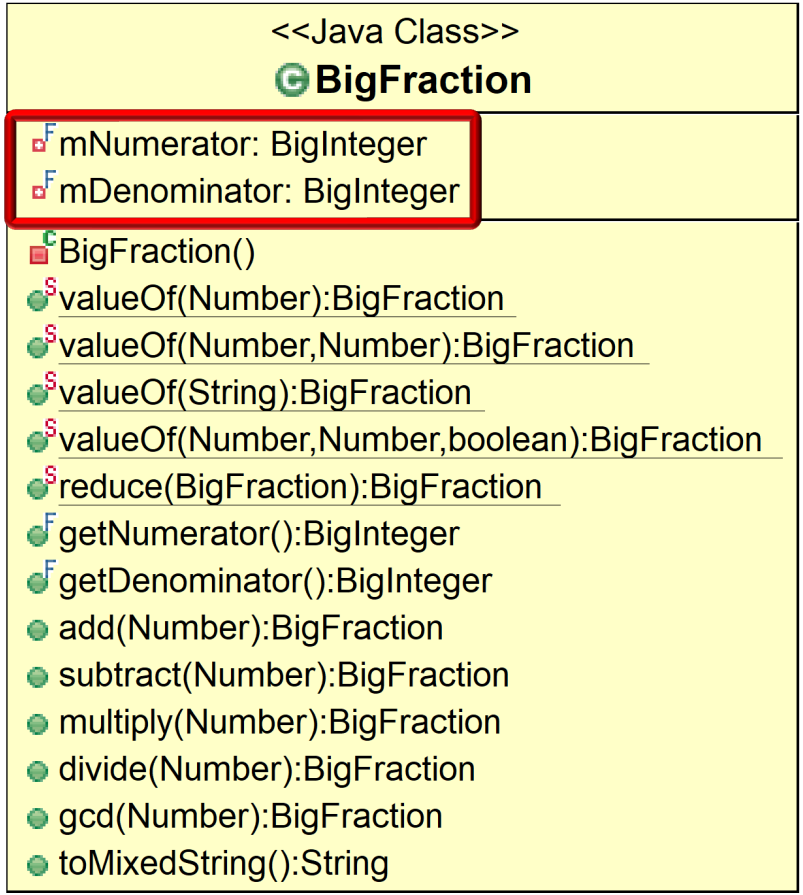
- We show how to apply Java futures in the context of a BigFraction class



See LiveLessons/blob/master/Java8/ex8/src/utils/BigFraction.java

Overview of the BigFraction Class

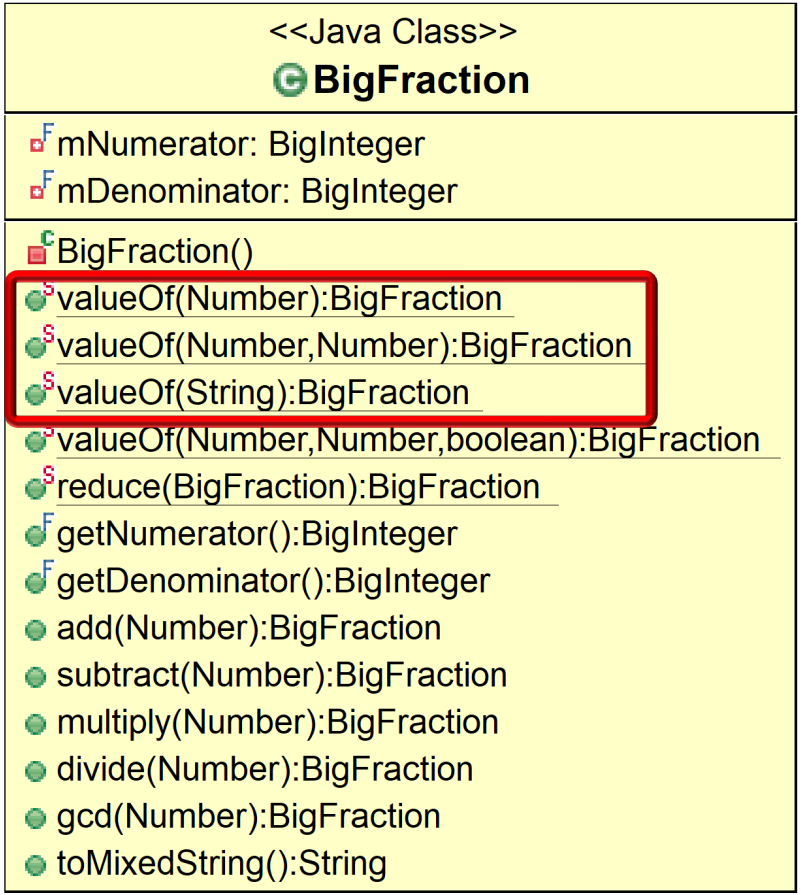
- We show how to apply Java futures in the context of a BigFraction class
  - Arbitrary-precision fraction, utilizing BigIntegers for numerator & denominator



See docs.oracle.com/javase/8/docs/api/java/math/BigInteger.html

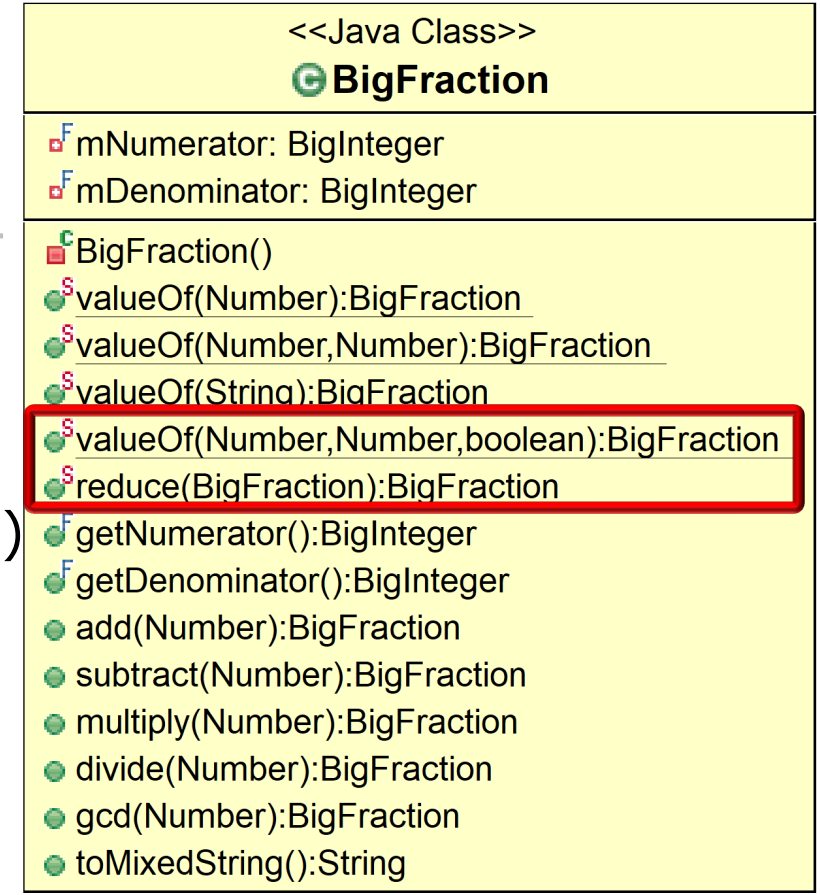
Overview of the BigFraction Class

- We show how to apply Java futures in the context of a BigFraction class
  - Arbitrary-precision fraction, utilizing BigIntegers for numerator & denominator
  - Factory methods for creating "reduced" fractions, e.g.
    - 44/55 → 4/5
    - 12/24 → 1/2
    - 144/216 → 2/3



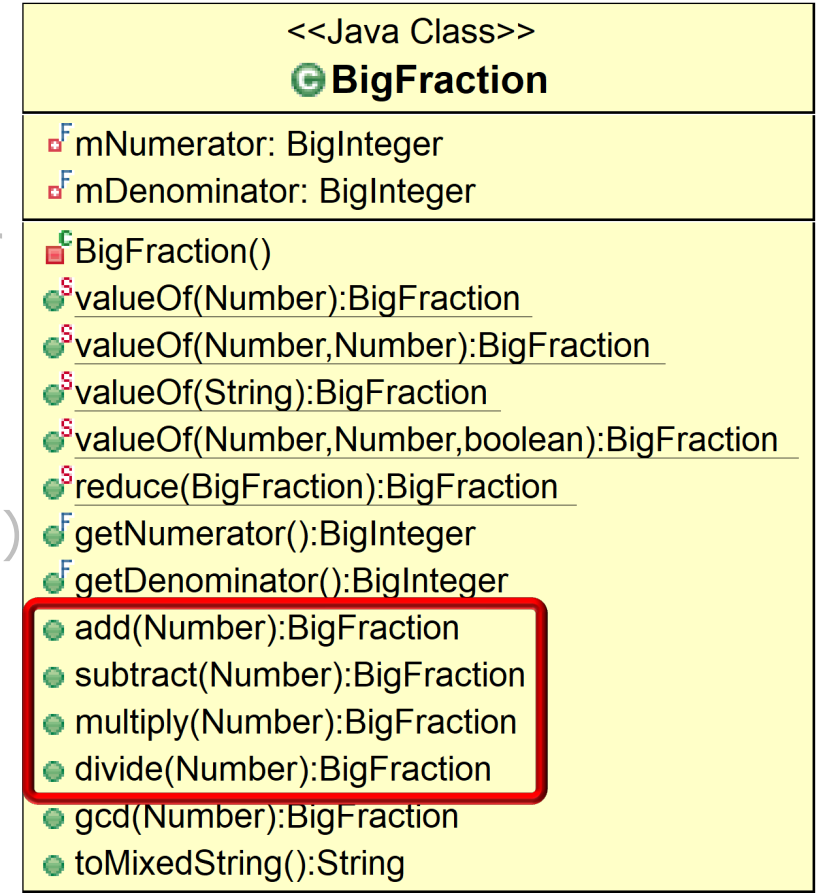
Overview of the BigFraction Class

- We show how to apply Java futures in the context of a BigFraction class
  - Arbitrary-precision fraction, utilizing BigIntegers for numerator & denominator
  - Factory methods for creating "reduced" fractions
  - Factory methods for creating "non-reduced" fractions (& then reducing them)
    - e.g., 12/24 (→ 1/2)



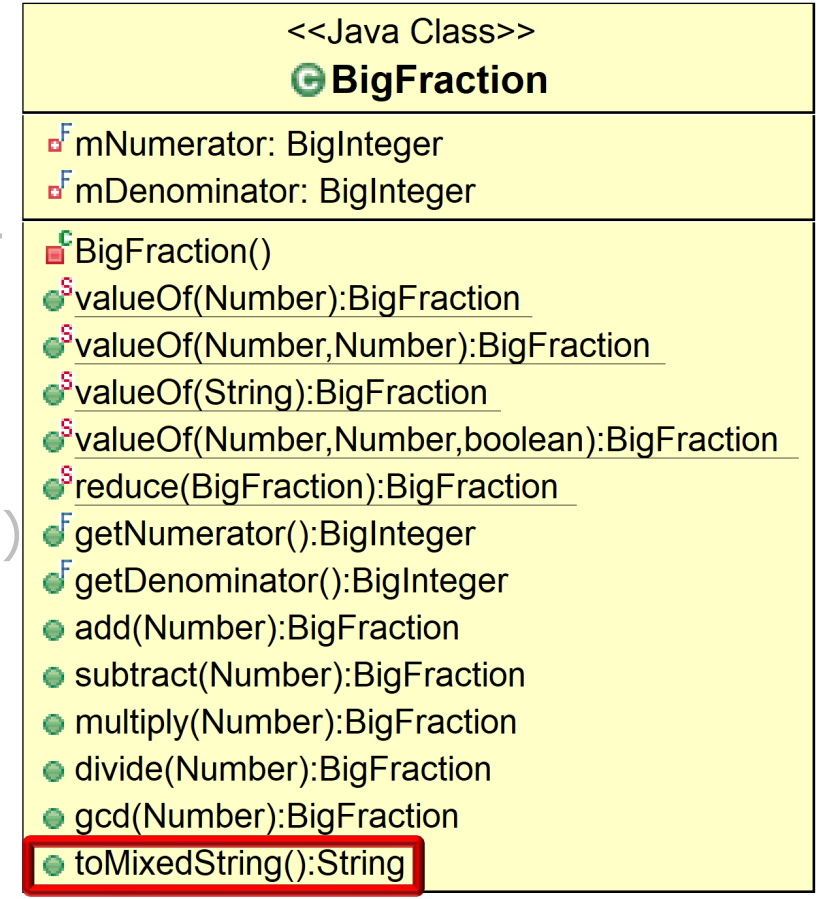
Overview of the BigFraction Class

- We show how to apply Java futures in the context of a BigFraction class
  - Arbitrary-precision fraction, utilizing BigIntegers for numerator & denominator
  - Factory methods for creating "reduced" fractions
  - Factory methods for creating "non-reduced" fractions (& then reducing them)
  - Arbitrary-precision fraction arithmetic
    - e.g., 18/4 ×2/3 = 3



Overview of the BigFraction Class

- We show how to apply Java futures in the context of a BigFraction class
  - Arbitrary-precision fraction, utilizing BigIntegers for numerator & denominator
  - Factory methods for creating "reduced" fractions
  - Factory methods for creating "non-reduced" fractions (& then reducing them)
  - Arbitrary-precision fraction arithmetic
  - Create a mixed fraction from an improper fraction
    - e.g., 18/4 → 4 1/2



See www.mathsisfun.com/improper-fractions.html

Programming BigFraction Objects with Java Futures

Programming BigFraction Objects with Java Futures

- Example of using Java Future via a Callable & the common fork-join pool

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

Callable<BigFraction> task = () -> {
  BigFraction bf1 =
    new BigFraction(f1);
  BigFraction bf2 =
    new BigFraction(f2);
  return bf1.multiply(bf2); };

Future<BigFraction> future =
  commonPool().submit(task);
...
BigFraction result =
  future.get();
```

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

Programming BigFraction Objects with Java Futures

- Example of using Java Future via a Callable & the common fork-join pool

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  return bf1.multiply(bf2); };

Future<BigFraction> future =
  commonPool().submit(task);
...
BigFraction result =
  future.get();
```

Callable is a two-way task that returns a result via a single method with "no" arguments

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

Programming BigFraction Objects with Java Futures

- Example of using Java Future via a Callable & the common fork-join pool

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Future<BigFraction> future =
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BigFraction result =
  future.get();
```

Java enables the initialization of a Callable via a lambda expression

See lesson on "*Overview of Java Lambda Expressions and Method References*"

Programming BigFraction Objects with Java Futures

- Example of using Java Future via a Callable & the common fork-join pool

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  return bf1.multiply(bf2); };

Future<BigFraction> future =
  commonPool().submit(task);
...
BigFraction result =
  future.get();
```

Can pass values to a Callable via effectively final variables

See javarevisited.blogspot.com/2015/03/what-is-effectively-final-variable-of.html

Programming BigFraction Objects with Java Futures

- Example of using Java Future via a Callable & the common fork-join pool

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     new BigFraction(f2);
   return bf1.multiply(bf2); };

Future<BigFraction> future =
   commonPool().submit(task);
...
BigFraction result =
   future.get();
```

Submit a two-way task to run in a thread pool (in this case the common fork-join pool)

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

Programming BigFraction Objects with Java Futures

- Example of using Java Future via a Callable & the common fork-join pool

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  return bf1.multiply(bf2); };

Future<BigFraction> future =
  commonPool().submit(task);
...
BigFraction result =
  future.get();
```

submit() returns a Future representing the pending results of the task

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

Programming BigFraction Objects with Java Futures

- Example of using Java Future via a Callable & the common fork-join pool

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String f1 = "62675744/15668936";
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   return bf1.multiply(bf2); };

Future<BigFraction> future =
   commonPool().submit(task);
...
BigFraction result =
   future.get();
```

Other code can run here concurrently wrt the task running in the background

Programming BigFraction Objects with Java Futures

- Example of using Java Future via a Callable & the common fork-join pool

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   return bf1.multiply(bf2); };

Future<BigFraction> future =
   commonPool().submit(task);
...
BigFraction result =
   future.get();
```

get() blocks if necessary for the computation to complete & then retrieves its result

See docs.oracle.com/javase/8/docs/api/java/util/concurrent/Future.html#get

Programming BigFraction Objects with Java Futures

- Example of using Java Future via a Callable & the common fork-join pool

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  return bf1.multiply(bf2); };

Future<BigFraction> future =
  commonPool().submit(task);
...
BigFraction result =
  future.get(n, SECONDS);
```

get() can also perform polling & timed-waits

See docs.oracle.com/javase/8/docs/api/java/util/concurrent/Future.html#get

End of Applying Java Futures in Practice