Overview of Advanced Java 8 CompletableFuture Features (Part 3)

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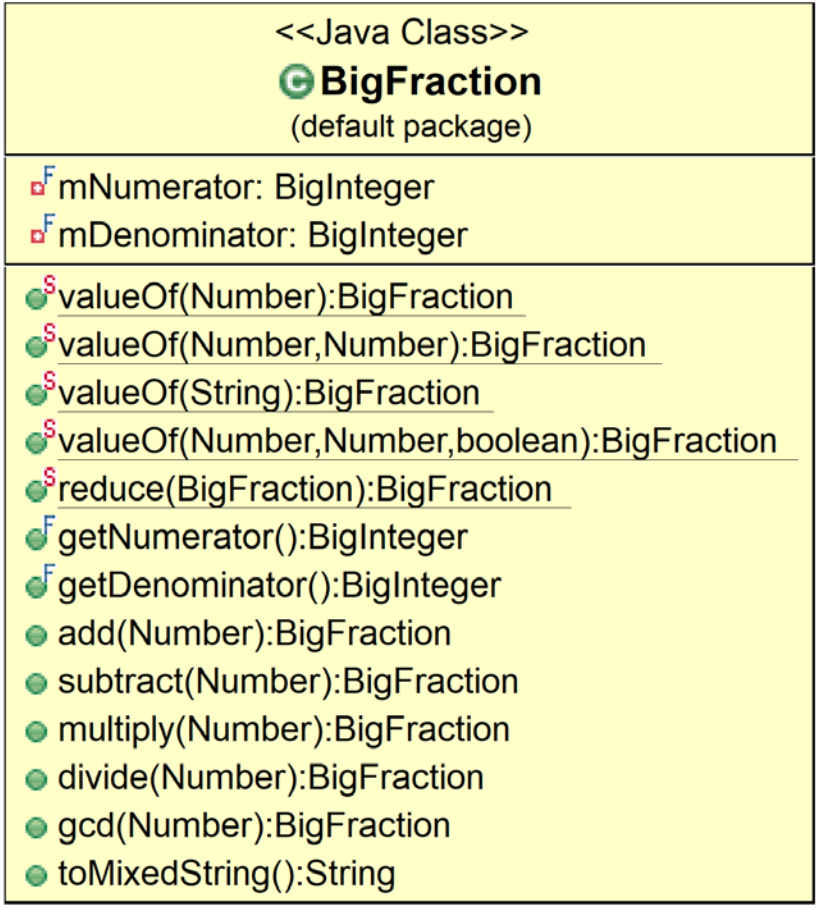
Learning Objectives in this Part of the Lesson

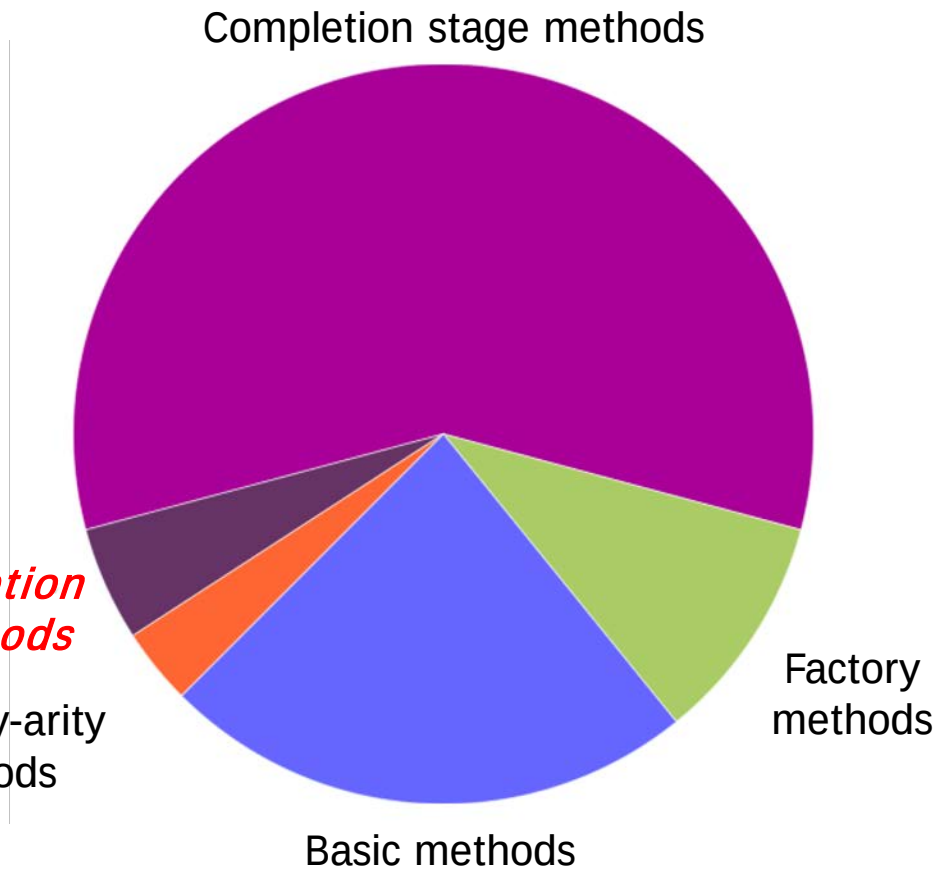
- Understand advanced features of completable futures, e.g.
  - Factory methods that initiate async functionality
  - Completion stage methods used to chain together actions that perform async result processing & composition
    - Apply completion stage methods to BigFractions



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

Learning Objectives in this Part of the Lesson

- Understand advanced features of completable futures, e.g.
  - Factory methods that initiate async functionality
  - Completion stage methods used to chain together actions that perform async result processing & composition
    - Apply completion stage methods to BigFractions
    - Know how to handle runtime exceptions



Applying Completable Future Completion Stage Methods

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- We show key completion stage methods via the testFractionMultiplications() method that multiplies big fractions using a stream of CompletableFutures

```
static void testFractionMultiplications() {
  ...
  Stream.generate(() -> makeBigFraction(new Random(), false))

        .limit(sMAX_FRACTIONS)

        .map(reduceAndMultiplyFractions)

        .collect(FuturesCollector.toFuture())

        .thenAccept(printSortedList);
}
```

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

Applying Completable Future Completion Stage Methods

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```
static void testFractionMultiplications() {
  Function<BigFraction, CompletableFuture<BigFraction>>
    reduceAndMultiplyFraction = unreducedFrac ->
      CompletableFuture

        .supplyAsync(() -> BigFraction.reduce(unreducedFrac))

        .thenCompose(reducedFrac -> CompletableFuture

                     .supplyAsync(() -> reducedFrac
                                  .multiply(sBigFraction)));
  ...
```

Lambda that asynchronously reduces/multiplies a big fraction

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  ...
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Asynchronously reduce a big fraction

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```

thenCompose() acts like flatMap()

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        .thenCompose(reducedFrac -> CompletableFuture
                       .supplyAsync(() -> reducedFrac
                                      .multiply(sBigFraction)));
  ...
```

Asynchronously multiply big fractions

Applying Completable Future Completion Stage Methods

- We show key completion stage methods via the testFractionMultiplications() method that multiplies big fractions using a stream of CompletableFutures

```
static void testFractionMultiplications() {
  ...
  Consumer<List<BigFraction>> printSortedList = list -> {
    CompletableFuture<List<BigFraction>> quickSortF =
      CompletableFuture.supplyAsync(() -> quickSort(list));


    CompletableFuture<List<BigFraction>> mergeSortF =
      CompletableFuture.supplyAsync(() -> mergeSort(list));

    quickSortF.acceptEither(mergeSortF, results ->
      results.forEach(frac -> display(frac.toMixedString())));
  }; ...
```

Sorts & prints a list of reduced fractions

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    quickSortF.acceptEither(mergeSortF, results ->
      results.forEach(frac -> display(frac.toMixedString())));
  }; ...
```

Asynchronously apply quick sort & merge sort!

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    quickSortF.acceptEither(mergeSortF, results ->
      results.forEach(frac -> display(frac.toMixedString())));
  }; ...
```

Select whichever result finishes first..

Applying Completable Future Completion Stage Methods

- We show key completion stage methods via the testFractionMultiplications() method that multiplies big fractions using a stream of CompletableFutures

```
static void testFractionMultiplications() {
  ...
  Stream.generate(() -> makeBigFraction(new Random(), false))

        .limit(sMAX_FRACTIONS)

        .map(reduceAndMultiplyFraction)

        .collect(FuturesCollector.toFuture())

        .thenAccept(printSortedList);
}
```

Generate a bounded # of large & random fractions

Applying Completable Future Completion Stage Methods

- We show key completion stage methods via the testFractionMultiplications() method that multiplies big fractions using a stream of CompletableFutures

```
BigFraction makeBigFraction(Random random, boolean reduced) {
  BigInteger numerator =
    new BigInteger(150000, random);

  BigInteger denominator =
    numerator.divide(BigInteger.valueOf(random.nextInt(10)
                                        + 1));

  return BigFraction.valueOf(numerator,
                             denominator,
                             reduced);
}
```

Factory method that creates a large & random fraction

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         .thenAccept(printSortedList);
}
```

Reduce & multiply these fractions asynchronously

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         .thenAccept(printSortedList);
}
```

Return a future to a list of big fractions being reduced & multiplied asynchronously

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        .thenAccept(printSortedList);
}
```

Sort & print results when all async computations complete

Handling Runtime Exceptions in Completion Stages

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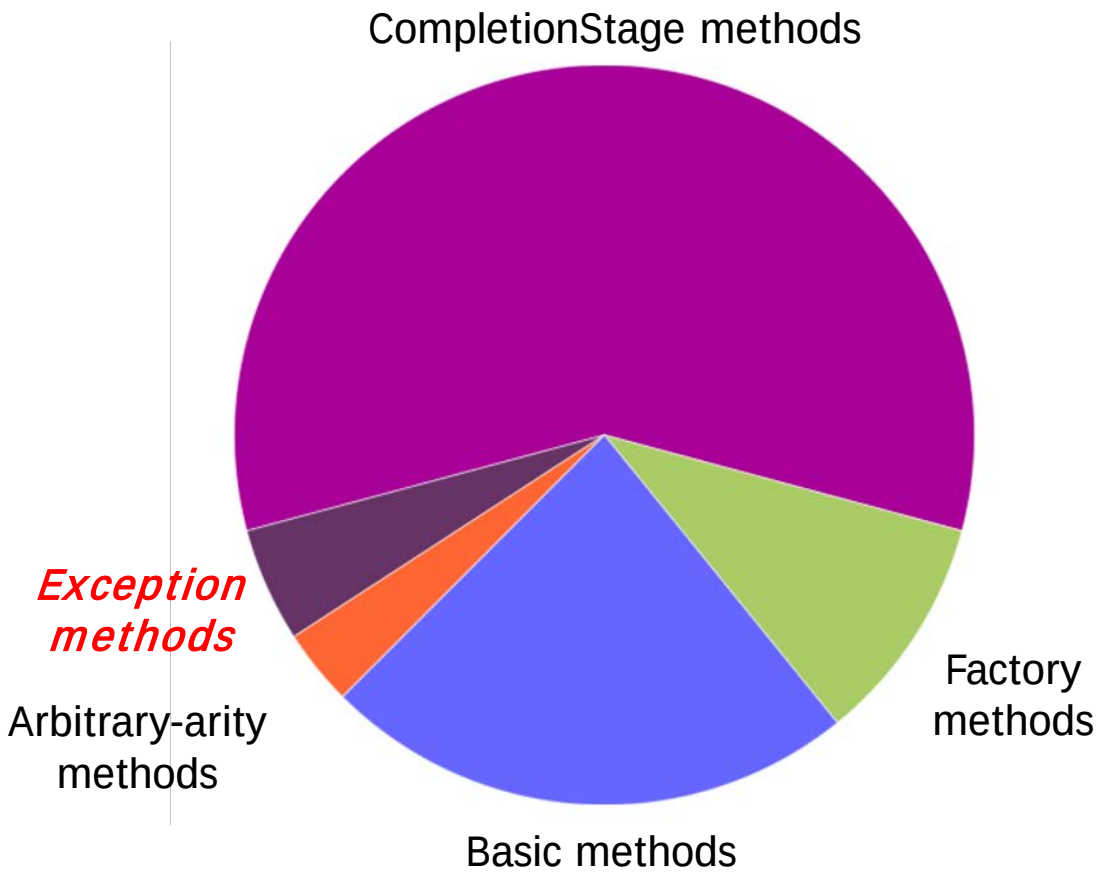
- Completion stage methods handle runtime exceptions



See www.jesperdj.com/2015/09/26/the-future-is-completable-in-java-8

Handling Runtime Exceptions in Completion Stages

- Completion stage methods handle runtime exceptions

Methods	Params	Returns	Behavior
whenComplete (Async)	BiConsumer	CompletableFuture with result of earlier stage or throws exception	Handle outcome of a stage, whether a result value or an exception
handle (Async)	BiFunction	CompletableFuture with result of BiFunction	Handle outcome of a stage & return new value
exceptionally	Function	CompletableFuture <Void>	When exception occurs, replace exception with result value

See community.oracle.com/docs/DOC-995305

Handling Runtime Exceptions in Completion Stages

- Using the handle() method to handle exceptional or normal completions

```
CompletableFuture
   .supplyAsync(() ->
                BigFraction.valueOf(100, denominator))

   .handle((fraction, ex) -> {
           if (fraction == null)
             return BigFraction.ZERO;
           else
             return fraction.multiply(sBigReducedFraction);
       })

   .thenAccept(fraction ->
               System.out.println(fraction.toMixedString()));
```

Handle outcome of previous stage

Handling Runtime Exceptions in Completion Stages

- Using the handle() method to handle exceptional or normal completions

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The exception path

Handling Runtime Exceptions in Completion Stages

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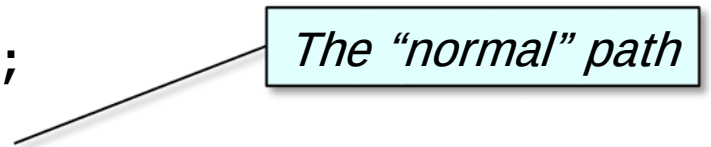

Handling Runtime Exceptions in Completion Stages

- Using the exceptionally() method to handle exceptional or normal completions

```
CompletableFuture
   .supplyAsync(() ->
                 BigFraction.valueOf(100, denominator))

   .thenApply(fraction ->
              fraction.multiply(sBigReducedFraction))

   .exceptionally(ex -> BigFraction.ZERO)

   .thenAccept(fraction ->
                System.out.println(fraction.toMixedString()));
```

End of Overview of Advanced Java 8 Completable Future Features (Part 3)