

Advanced Java CompletableFuture Features: Handling Runtime Exceptions (Part 2)

Douglas C. Schmidt

d.schmidt@vanderbilt.edu

www.dre.vanderbilt.edu/~schmidt



Professor of Computer Science

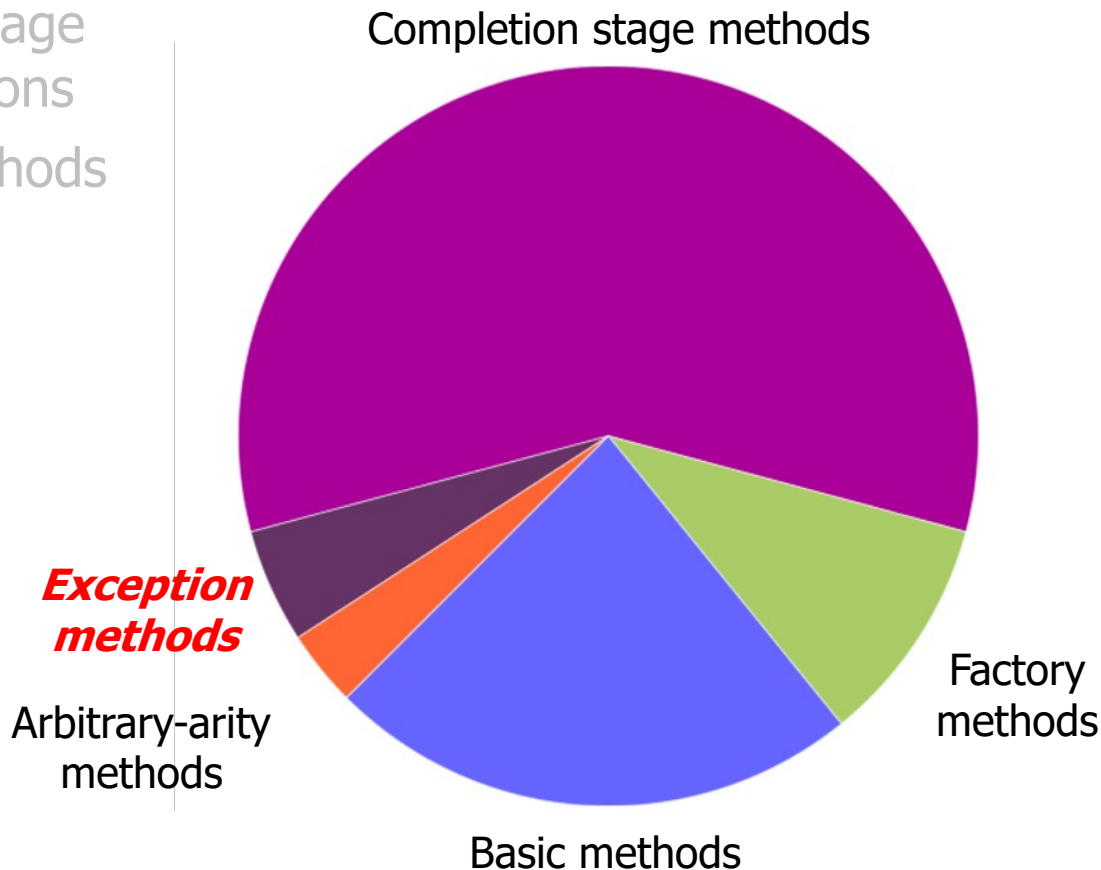
**Institute for Software
Integrated Systems**

**Vanderbilt University
Nashville, Tennessee, USA**



Learning Objectives in this Part of the Lesson

- Understand how completion stage methods chain dependent actions
- Know how to group these methods
- Single stage methods
- Two stage methods (and)
- Two stage methods (or)
- Apply these methods
- Handle runtime exceptions
 - Sync vs. async exceptions
 - Overview of methods
 - Applying these methods



Examples of Handling Exceptions in Completion Stages

Examples of Handling Exceptions in Completion Stages

- This example shows three ways to handle exceptions w/completable futures

CompletableFuture

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

...

*An exception will occur if
denominator param is 0!*

Examples of Handling Exceptions in Completion Stages

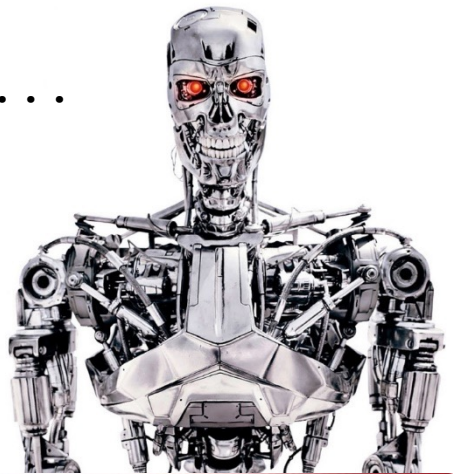
- This example shows three ways to handle exceptions w/completable futures

`CompletableFuture`

```
.supplyAsync(() ->
```

```
    BigFraction.valueOf(100, denominator))
```

`...`



TERMINATED

*An unhandled exception
will terminate a program!*

Examples of Handling 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);  
}))
```

Handle outcome of the previous stage (always called, regardless of whether an exception is thrown)

```
.thenAccept(fraction ->
```

```
    System.out.println(fraction.toMixedString()));
```

Examples of Handling 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()));
```

These values are mutually exclusive

Examples of Handling 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()));
```

The exception path converts ("swallows") an exception & returns `BigFraction.ZERO`

Examples of Handling 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()));
```

The "normal" path

Examples of Handling 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() must return a value (& can thus change the return value)

Examples of Handling 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()));
```

Display result as a mixed fraction

Examples of Handling 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()));
```

Examples of Handling Exceptions in Completion Stages

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

CompletableFuture

An exception occurs if denominator is 0!

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

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

.exceptionally(ex -> BigFraction.ZERO)

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

Examples of Handling 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)
```

Handle case where denominator != 0 (skipped if exception is thrown)

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

Examples of Handling 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()));
```

Handle case where denominator == 0 & exception is thrown (otherwise skipped)

`exceptionally()` is akin to `catch()` in a Java try/catch block, i.e., control xfers to it

Examples of Handling 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)
```

Convert ("swallow") an exception to a 0 result

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

Examples of Handling 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))
```

```
.exceptionallyAsync(ex -> BigFraction.ZERO)
```

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

*Can be used if exception
handling takes a long time*

Examples of Handling 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)
```

Display result as a mixed fraction

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

Examples of Handling Exceptions in Completion Stages

- Using the `whenComplete()` method to perform an exceptional or normal action

```
CompletableFuture
```

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

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

Called under both normal & exception conditions

```
.whenComplete((fraction, ex) -> {  
    if (fraction != null)  
        System.out.println(fraction.toMixedString());  
    else  
        System.out.println(ex.getMessage());  
});
```

Examples of Handling Exceptions in Completion Stages

- Using the `whenComplete()` method to perform an exceptional or normal action

```
CompletableFuture
```

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

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

```
.whenComplete((fraction, ex) -> {  
    if (fraction != null)  
        System.out.println(fraction.toMixedString());  
    else  
        System.out.println(ex.getMessage());  
});
```

These values are mutually exclusive

Examples of Handling Exceptions in Completion Stages

- Using the `whenComplete()` method to perform an exceptional or normal action

```
CompletableFuture
```

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

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

```
.whenComplete((fraction, ex) -> {  
    if (fraction != null)  
        System.out.println(fraction.toMixedString());  
    else  
        System.out.println(ex.getMessage());  
});
```

Handle the normal case

Examples of Handling Exceptions in Completion Stages

- Using the `whenComplete()` method to perform an exceptional or normal action

```
CompletableFuture
```

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

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

```
.whenComplete((fraction, ex) -> {  
    if (fraction != null)  
        System.out.println(fraction.toMixedString());  
    else // ex != null  
        System.out.println(ex.getMessage());  
});
```

*Handle the
exceptional case*

Examples of Handling Exceptions in Completion Stages

- Using the `whenComplete()` method to perform an exceptional or normal action

```
CompletableFuture
```

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

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

```
.whenComplete((fraction,  
    if (fraction != null)  
        System.out.println(fraction.toMixedString());  
    else // ex != null  
        System.out.println(ex.getMessage());  
    ));
```

*whenComplete() is like Java Streams.peek(),
i.e., it has a side-effect, doesn't change the
return value, & doesn't swallow the exception*

See docs.oracle.com/javase/8/docs/api/java/util/stream/Stream.html#peek

End of Advanced Java CompletableFuture Features: Handling Runtime Exceptions (Part 2)