

The Java CompletableFuture ImageStreamGang Case Study: Applying Completion Stage Methods (Part 1)

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 the design of the Java completable future version of ImageStreamGang
- Know how to apply completable futures to ImageStreamGang, e.g.
 - Factory methods
 - Completion stage methods
 - thenApplyAsync()
 - & Java Streams map()

<<Java Class>>	
G CompletableFuture<T>	
•	CompletableFuture()
•	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>
•	allOf(CompletableFuture[]<?>):CompletableFuture<Void>
•	anyOf(CompletableFuture[]<?>):CompletableFuture<Object>

Applying Completion Stage Methods in DownloadImageAsync

Applying Completion Stage Methods in DownloadImageAsync

- Asynchronously download an image at each given URL

```
void processStream() {  
    List<URL> urls = getInput();
```

```
    CompletableFuture<Stream<Image>>  
        resultsFuture = urls  
            .stream()  
            .map(this::checkUrlCachedAsync)  
            .map(this::downloadImageAsync)  
            .flatMap(this::applyFiltersAsync)  
            .collect(toFuture())  
            .thenApply(stream ->  
                log(stream.flatMap  
                    (Optional::stream),  
                    urls.size()))  
            .join();
```

*map() calls the behavior
downloadImageAsync()*

Applying Completion Stage Methods in DownloadImageAsync

- Asynchronously download an image at each given URL

```
void processStream() {  
    List<URL> urls = getInput();
```

Asynchronously downloads an image & stores it in memory

```
CompletableFuture<Stream<Image>>  
    resultsFuture = urls  
        .stream()  
        .map(this::checkUrlCachedAsync)  
        .map(this::downloadImageAsync)  
        .flatMap(this::applyFiltersAsync)  
        .collect(toFuture())  
        .thenApply(stream ->  
            log(stream.flatMap  
                (Optional::stream),  
                urls.size()))  
        .join();
```



Later behaviors simply ignore "empty" optional images

Applying Completion Stage Methods in DownloadImageAsync

- Asynchronously download an image at each given URL

```
void processStream() {  
    List<URL> urls = getInput();
```

Returns a stream of futures to optional images, which have a value if the image is being downloaded or are empty if it is already cached

```
CompletableFuture<Stream<Image>>  
    resultsFuture = urls  
        .stream()  
        .map(this::checkUrlCachedAsync)  
        .map(this::downloadImageAsync)  
        .flatMap(this::applyFiltersAsync)  
        .collect(toFuture())  
        .thenApply(stream ->  
            log(stream.flatMap  
                (Optional::stream),  
                urls.size()))  
        .join();
```

Applying Completion Stage Methods in DownloadImageAsync

- downloadImageAsync() uses the thenApplyAsync() method internally

```
CompletableFuture<Optional<Image>> downloadImageAsync
    (CompletableFuture<Optional<URL>> urlFuture) {
    return urlFuture
        .thenApplyAsync(urlOpt ->
            urlOpt
                .map(this::blockingDownload) ,
            getExecutor()) ;
}
```

*Asynchronously download
image when future completes*

See imagestreamgang.streams/ImageStreamCompletableFuture1.java

Applying Completion Stage Methods in DownloadImageAsync

- downloadImageAsync() uses the thenApplyAsync() method internally

```
CompletableFuture<Optional<Image>> downloadImageAsync  
    (CompletableFuture<Optional<URL>> urlFuture) {  
    return urlFuture  
        .thenApplyAsync(urlOpt ->  
            urlOpt  
            .map(this::blockingDownload) ,  
            getExecutor() ) ;  
}
```

This completion stage method registers an action that's not executed immediately, but only after urlFuture completes

Applying Completion Stage Methods in DownloadImageAsync

- downloadImageAsync() uses the thenApplyAsync() method internally

```
CompletableFuture<Optional<Image>> downloadImageAsync  
    (CompletableFuture<Optional<URL>> urlFuture) {  
    return urlFuture  
        .thenApplyAsync(urlOpt ->  
            urlOpt  
                .map(this::blockingDownload) ,  
            getExecutor() ) ;  
}
```

If a url is present, then download it when urlFuture completes & return an optional describing the result; otherwise return an empty optional

Applying Completion Stage Methods in DownloadImageAsync

- downloadImageAsync() uses the thenApplyAsync() method internally

```
CompletableFuture<Optional<Image>> downloadImageAsync  
    (CompletableFuture<Optional<URL>> urlFuture) {  
    return urlFuture  
        .thenApplyAsync(urlOpt ->  
            urlOpt  
            .map(this::blockingDownload) ,  
            getExecutor() );  
}
```

Asynchronously run blockingDownload() if urlOpt is non-empty

Applying Completion Stage Methods in DownloadImageAsync

- downloadImageAsync() uses the thenApplyAsync() method internally

```
CompletableFuture<Optional<Image>> downloadImageAsync  
    (CompletableFuture<Optional<URL>> urlFuture) {  
    return urlFuture  
        .thenApplyAsync(urlOpt ->  
            urlOpt  
                .map(this::blockingDownload) ,  
                getExecutor()) ;  
}
```



*Use the common fork-join pool &
its ManagedBlocker mechanism*

See earlier lesson on "The Java Fork-Join Pool: The ManagedBlocker Interface"

Applying Completion Stage Methods in DownloadImageAsync

- downloadImageAsync() uses the thenApplyAsync() method internally

```
Image blockingDownload(URL url) {  
    return BlockingTask  
        .callInManagedBlock(() ->  
            downloadImage(url));  
}
```

*Transform a URL into an Image by
downloading each image via the URL*

See [imagestreamgang/streams/ImageStreamGang.java](https://github.com/akka/imagestreamgang/blob/master/streams/ImageStreamGang.java)

Applying Completion Stage Methods in DownloadImageAsync

- downloadImageAsync() uses the thenApplyAsync() method internally

```
Image blockingDownload(URL url) {  
    return BlockingTask  
        .callInManagedBlock(( ) ->  
                               downloadImage(url));  
}
```

BlockingTask.callInManagedBlock() wraps the ManagedBlocker interface, which auto-expands the common fork-join pool to handle the blocking image download

See [imagestreamgang/Utils/BlockingTask.java](https://github.com/imagestreamgang/Utils/blob/master/BlockingTask.java)

Applying Completion Stage Methods in DownloadImageAsync

- downloadImageAsync() uses the thenApplyAsync() method internally

```
Image blockingDownload(URL url) {  
    return BlockingTask  
        .callInManagedBlock(() ->  
                                downloadImage(url));  
}
```

This blocking call actually downloads the image at the given url

```
Image downloadImage(URL url) {  
    return new Image(url,  
                    NetUtils.downloadContent(url));  
}
```

See imagestreamgang.streams/ImageStreamGang.java

Applying Completion Stage Methods in DownloadImageAsync

- downloadImageAsync() uses the thenApplyAsync() method internally

```
CompletableFuture<Optional<Image>> downloadImageAsync  
    (CompletableFuture<Optional<URL>> urlFuture) {  
    return urlFuture  
        .thenApplyAsync(urlOpt ->  
            urlOpt  
            .map(this::blockingDownload) ,  
            getExecutor() ) ;  
}
```

Returns a future to an optional image that will complete when the image finishes downloading

End of the Java Completable Future ImageStreamGang Case Study: Applying Completion Stage Methods (Part 1)
