Java Completable Futures ImageStreamGang Example: StreamOfFuturesCollector

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Learning Objectives in this Part of the Lesson

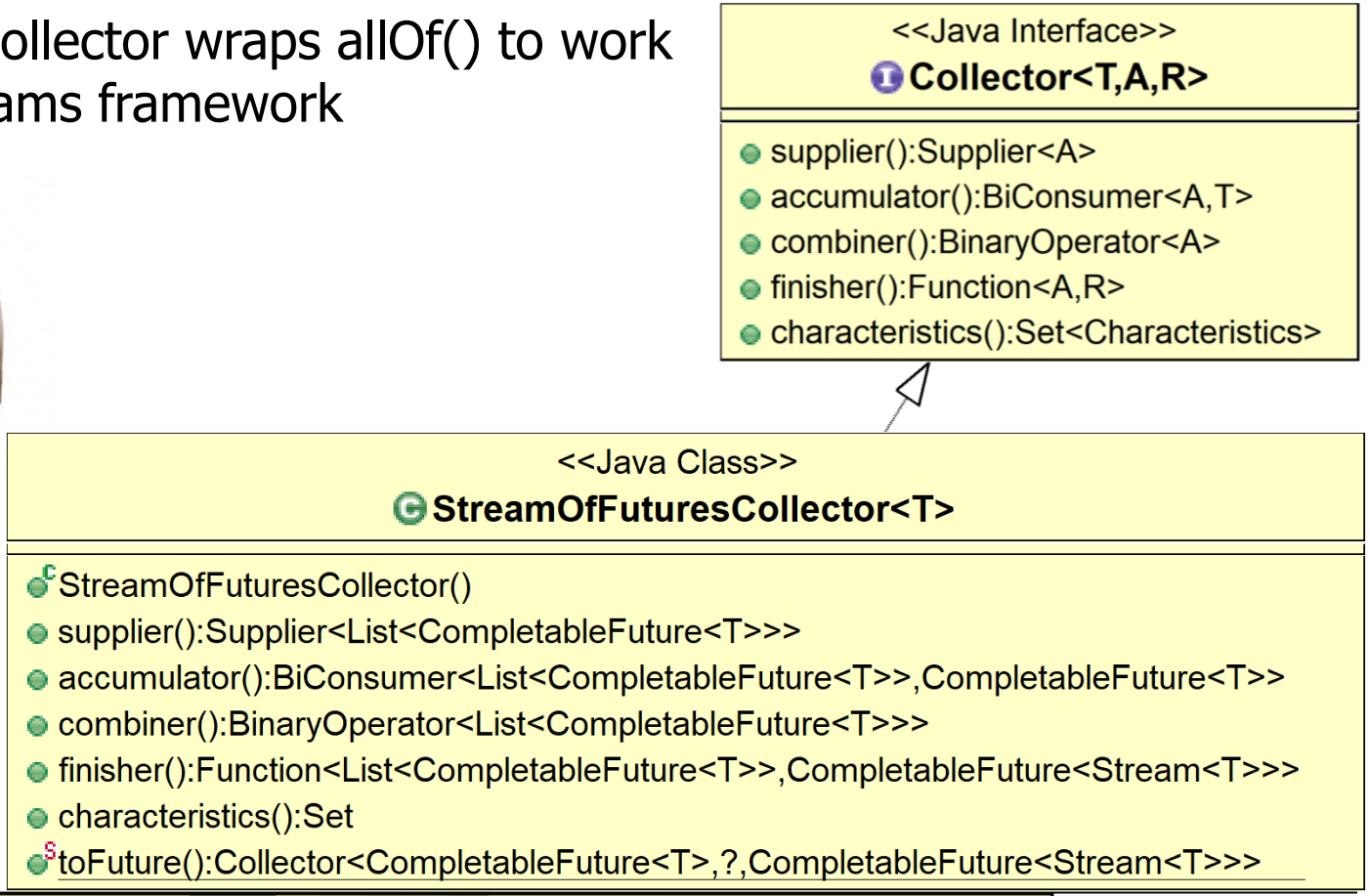
- Understand the design of the Java completable future version of ImageStreamGang
- Know how to apply completable futures to ImageStreamGang, e.g.
  - Factory methods
  - Completion stage methods
  - Arbitrary-arity methods
    - Wrap the allOf() method to work with the Java streams framework

```
<<Java Class>>
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>
```

Implementing the Class StreamOfFuturesCollector

Implementing the Class StreamOfFuturesCollector

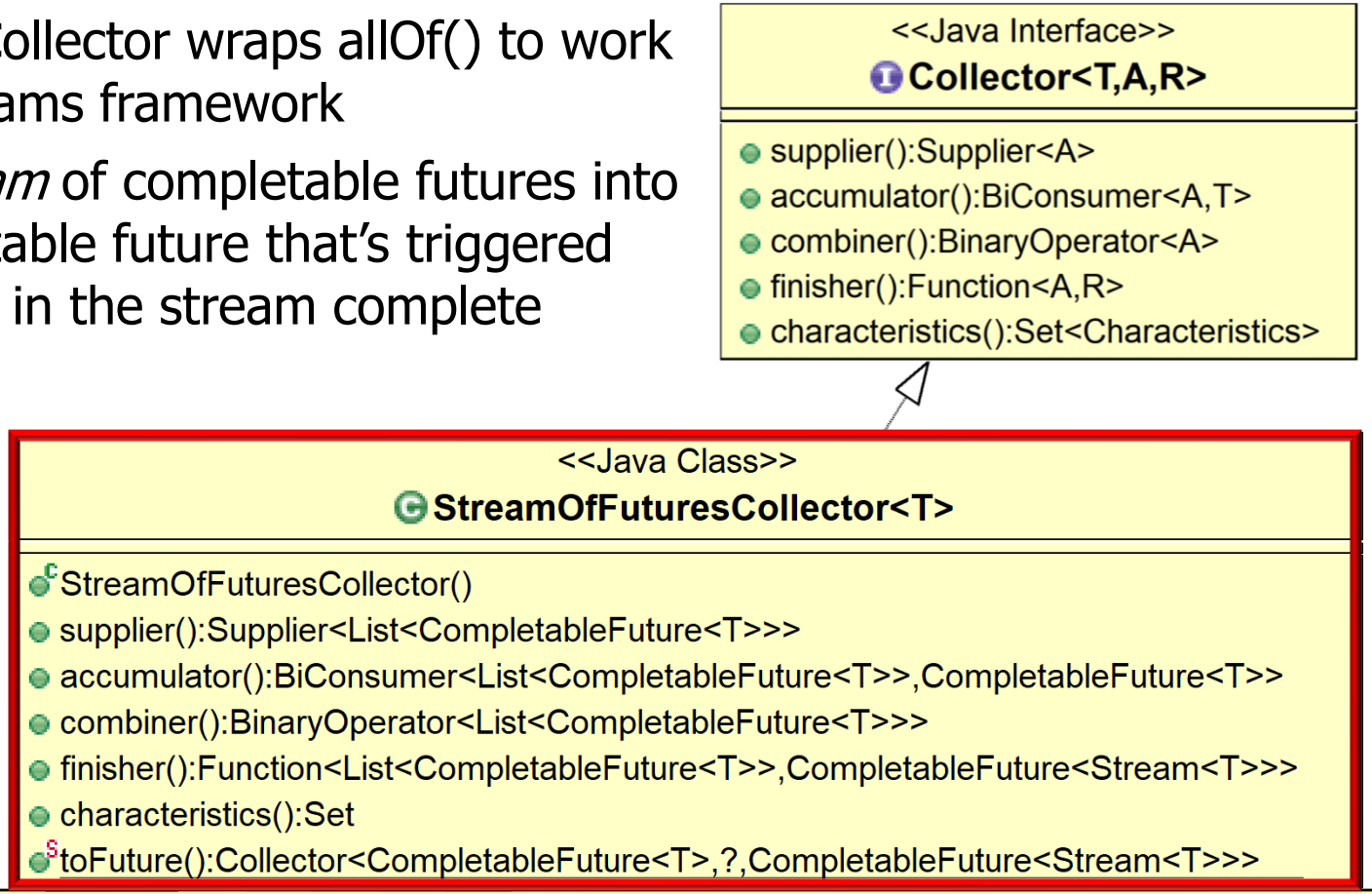
- StreamOfFuturesCollector wraps allOf() to work with the Java streams framework



See livelessons/utils/StreamOfFuturesCollector.java

Implementing the Class StreamOfFuturesCollector

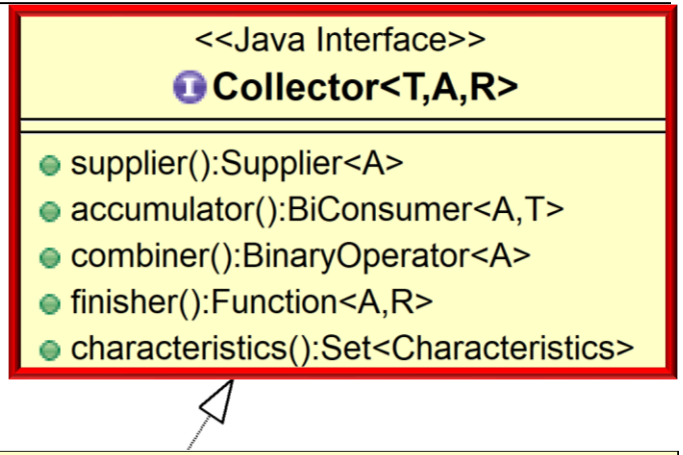
- StreamOfFuturesCollector wraps allOf() to work with the Java streams framework
  - Converts a *stream* of completable futures into a *single* completable future that's triggered when *all* futures in the stream complete

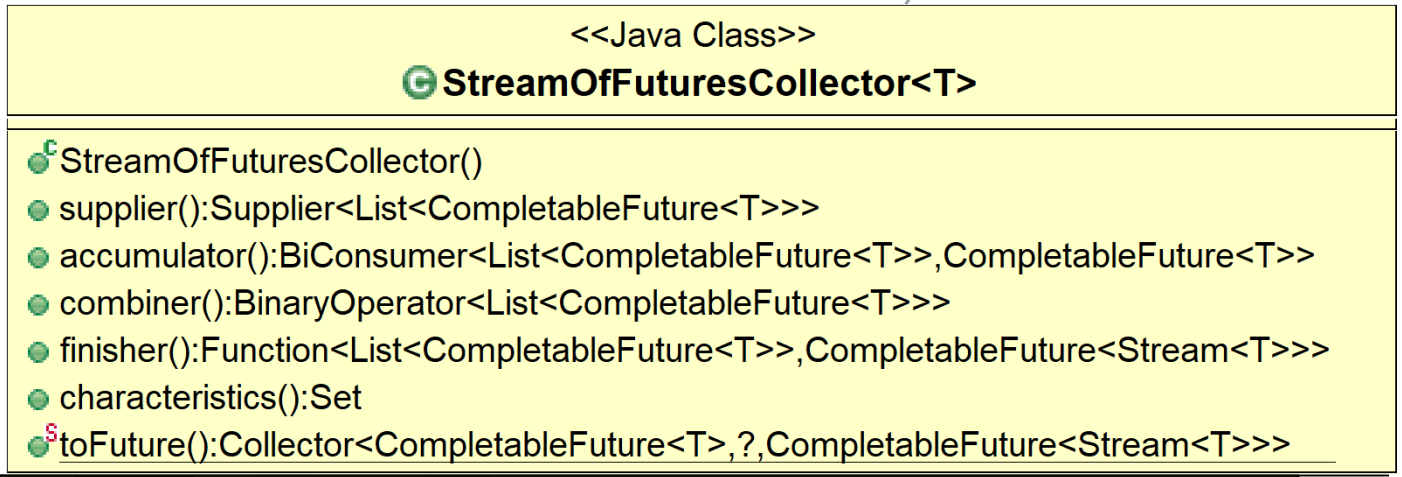


StreamOfFuturesCollector is a non-concurrent collector (supports parallel & sequential streams)

Implementing the Class StreamOfFuturesCollector

- StreamOfFuturesCollector wraps allOf() to work with the Java streams framework
  - Converts a *stream* of completable futures into a *single* completable future that's triggered when *all* futures in the stream complete
  - Implements the Collector interface





See docs.oracle.com/javase/8/docs/api/java/util/stream/Collector.html

Implementing the Class StreamOfFuturesCollector

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  - Converts a *stream* of completable futures into a *single* completable future that's triggered when *all* futures in the stream complete
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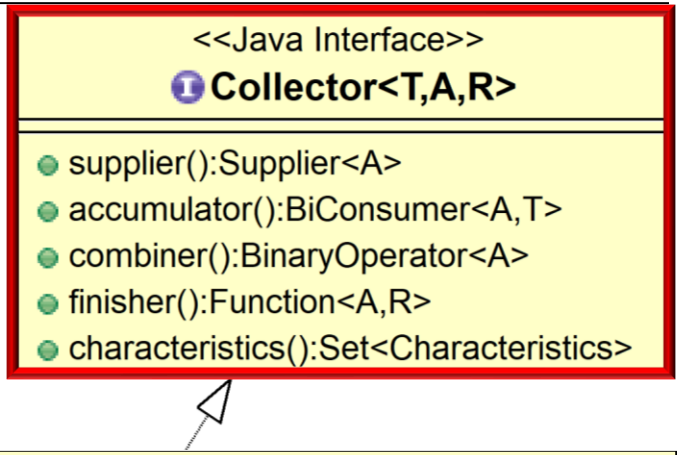
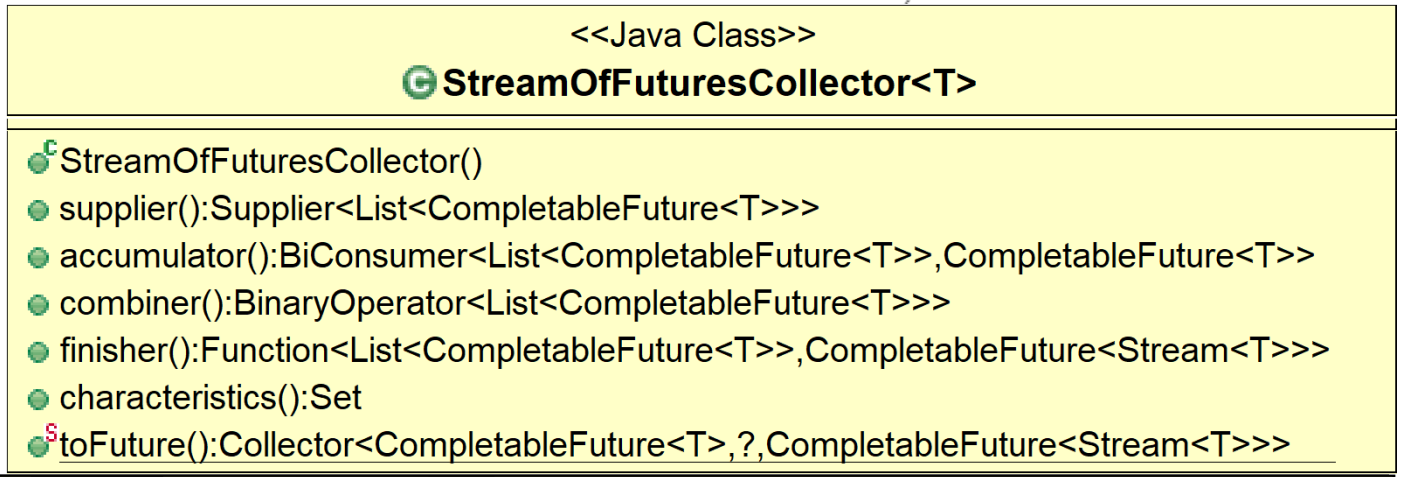
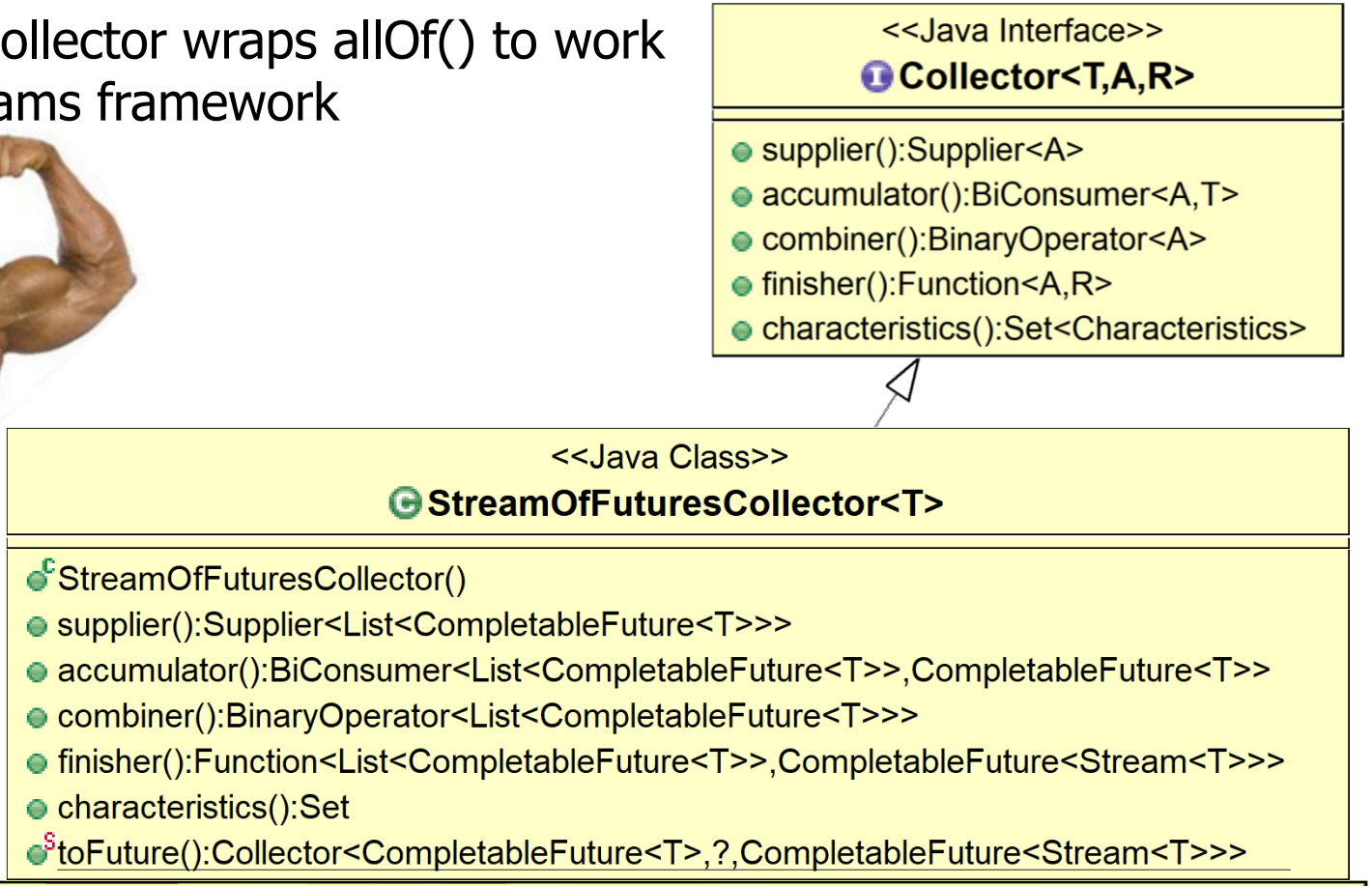




A collector accumulates input stream elements into a mutable result container

Implementing the Class StreamOfFuturesCollector

- StreamOfFuturesCollector wraps allOf() to work with the Java streams framework



StreamOfFuturesCollector provides a powerful wrapper for some complex code!

Implementing the Class StreamOfFuturesCollector

- StreamOfFuturesCollector implements all methods in the Collector interface

```
public class StreamOfFuturesCollector<T>
        implements Collector<CompletableFuture<T>,
                             List<CompletableFuture<T>>,
                             CompletableFuture<Stream<T>>> {
  ...
```

Implements a custom collector

See docs.oracle.com/javase/8/docs/api/java/util/stream/Collector.html

Implementing the Class StreamOfFuturesCollector

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public class StreamOfFuturesCollector<T>
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  ...
```

The type of input elements in the stream

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                             CompletableFuture<Stream<T>>> {
  ...
```

The mutable result container type

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                             List<CompletableFuture<T>>,
                             CompletableFuture<Stream<T>>> {
  ...
```

The result type of final output of the collector

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public class StreamOfFuturesCollector<T>
        implements Collector<CompletableFuture<T>,
                             List<CompletableFuture<T>>,
                             CompletableFuture<Stream<T>>> {
   ...
```

The Stream<T> parameter differs from the List<T> parameter applied by the previous FuturesCollector

See earlier lesson on "*Advanced Java Completable Future Features: Implementing FuturesCollector*"

Implementing the Class StreamOfFuturesCollector

- StreamOfFuturesCollector implements all methods in the Collector interface

```
public class StreamOfFuturesCollector<T>
        implements Collector<CompletableFuture<T>,
                             List<CompletableFuture<T>>,
                             CompletableFuture<Stream<T>>> {
  public Supplier<List<CompletableFuture<T>>> supplier() {
    return ArrayList::new;
  }

  public BiConsumer<List<CompletableFuture<T>>,
                    CompletableFuture<T>> accumulator()
  { return List::add; }
  ...
```

This factory method returns a supplier used by the Java streams collector framework to create a new mutable array list container

Implementing the Class StreamOfFuturesCollector

- StreamOfFuturesCollector implements all methods in the Collector interface

```
public class StreamOfFuturesCollector<T>
        implements Collector<CompletableFuture<T>,
                             List<CompletableFuture<T>>,
                             CompletableFuture<Stream<T>>> {
  public Supplier<List<CompletableFuture<T>>> supplier() {
    return ArrayList::new;
  }
```

This mutable result container stores a list of completable futures of type T

```
  public BiConsumer<List<CompletableFuture<T>>,
                    CompletableFuture<T>> accumulator()
  { return List::add; }
  ...
```

Implementing the Class StreamOfFuturesCollector

- StreamOfFuturesCollector implements all methods in the Collector interface

```
public class StreamOfFuturesCollector<T>
        implements Collector<CompletableFuture<T>,
                             List<CompletableFuture<T>>,
                             CompletableFuture<Stream<T>>> {
  public Supplier<List<CompletableFuture<T>>> supplier() {
    return ArrayList::new;
  }
```

This factory method returns a bi-consumer used by the Java streams collector framework to add a new completable future into the mutable array list container

```
  public BiConsumer<List<CompletableFuture<T>>,
                    CompletableFuture<T>> accumulator()
  { return List::add; }
  ...
```

This method is only ever called in a single thread (so no locks are needed)

Implementing the Class StreamOfFuturesCollector

- StreamOfFuturesCollector implements all methods in the Collector interface

```
public class StreamOfFuturesCollector<T>
  ...
  public BinaryOperator<List<CompletableFuture<T>>> combiner() {
    return (List<CompletableFuture<T>> one,
            List<CompletableFuture<T>> another) -> {
        one.addAll(another);
        return one;
    };
  }
  ...
```

This factory method returns a binary operator that merges two partial array list results into a single array list (only relevant for parallel streams)

This method is only ever called in a single thread (so no locks are needed)

Implementing the Class StreamOfFuturesCollector

- StreamOfFuturesCollector implements all methods in the Collector interface

```
public class StreamOfFuturesCollector<T>
  ...
  public Function<List<CompletableFuture<T>>,
                  CompletableFuture<Stream<T>>> finisher(){
    return futures -> CompletableFuture
      .allOf(futures.toArray(new CompletableFuture[0]))
```

This factory method returns a function used by the Java streams collector framework to transform the array list mutable result container to the completable future result type

```
      .thenApply(v -> futures.stream()
                              .map(CompletableFuture::join));
  }
  ...
```

Implementing the Class StreamOfFuturesCollector

- StreamOfFuturesCollector implements all methods in the Collector interface

```
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  ...
  public Function<List<CompletableFuture<T>>,
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    return futures -> CompletableFuture
      .allOf(futures.toArray(new CompletableFuture[0]))

      .thenApply(v -> futures.stream()
                                .map(CompletableFuture::join));
  }
  ...
```

Reference to the mutable result container, which is an ArrayList

Implementing the Class StreamOfFuturesCollector

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public class StreamOfFuturesCollector<T>
  ...
  public Function<List<CompletableFuture<T>>,
                  CompletableFuture<Stream<T>>> finisher(){
    return futures -> CompletableFuture
      .allOf(futures.toArray(new CompletableFuture[0]))
```

Convert the list of futures to an array of futures & pass to allOf() to obtain a future that will complete when all futures complete

```
      .thenApply(v -> futures.stream()
                              .map(CompletableFuture::join));
  }
  ...
```

Implementing the Class StreamOfFuturesCollector

- StreamOfFuturesCollector implements all methods in the Collector interface

```
public class StreamOfFuturesCollector<T>
  ...
  public Function<List<CompletableFuture<T>>,
                  CompletableFuture<Stream<T>>> finisher(){
    return futures -> CompletableFuture
      .allOf(futures.toArray(new CompletableFuture[0]))
```

When all futures have completed get a single future to a stream of joined elements of type T

```
      .thenApply(v -> futures.stream()
                              .map(CompletableFuture::join));
  }
  ...
```

Implementing the Class StreamOfFuturesCollector

- StreamOfFuturesCollector implements all methods in the Collector interface

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  ...
  public Function<List<CompletableFuture<T>>,
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    return futures -> CompletableFuture
      .allOf(futures.toArray(new CompletableFuture[0]))

      .thenApply(v -> futures.stream()
                                .map(CompletableFuture::join));
  }
  ...
```

Convert the array list of futures into a stream of futures

Implementing the Class StreamOfFuturesCollector

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```
public class StreamOfFuturesCollector<T>
  ...
  public Function<List<CompletableFuture<T>>,
                  CompletableFuture<Stream<T>>> finisher(){
    return futures -> CompletableFuture
      .allOf(futures.toArray(new CompletableFuture[0]))

      .thenApply(v -> futures.stream()
                                .map(CompletableFuture::join));
  }
  ...
```

This call to join() will never block!

Implementing the Class StreamOfFuturesCollector

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  ...
  public Function<List<CompletableFuture<T>>,
                  CompletableFuture<Stream<T>>> finisher(){
    return futures -> CompletableFuture
      .allOf(futures.toArray(new CompletableFuture[0]))
```

Return future to stream of elements of T since no terminal operation after map()

```
      .thenApply(v -> futures.stream()
                                .map(CompletableFuture::join));
  }
  ...
```

Implementing the Class StreamOfFuturesCollector

- toFuture() returns a future to a stream of futures to images that are being downloaded, filtered, & stored

```
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();
```

Provides a single means to await completion of a set of futures before continuing with the program

Implementing the Class StreamOfFuturesCollector

- toFuture() returns a future to a stream of futures to images that are being downloaded, filtered, & stored

```
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()))
```

thenApply() is called only after the future returned from collect() completes

Implementing the Class StreamOfFuturesCollector

- StreamOfFuturesCollector implements all methods in the Collector interface

```
public class StreamOfFuturesCollector<T>
  ...
  public Set characteristics() {
    return Collections.singleton(Characteristics.UNORDERED);
  }

  public static <T> Collector<CompletableFuture<T>, ?,
                                CompletableFuture<Stream<T>>>
  toFuture() {
    return new StreamOfFuturesCollector<>();
  }
}
```

Returns a set indicating the characteristics of the StreamOfFutureCollector class

StreamOfFuturesCollector is thus a *non-concurrent* collector

Implementing the Class StreamOfFuturesCollector

- StreamOfFuturesCollector implements all methods in the Collector interface

```
public class StreamOfFuturesCollector<T>
  ...
  public Set characteristics() {
    return Collections.singleton(Characteristics.UNORDERED);
  }

  public static <T> Collector<CompletableFuture<T>, ?,
                              CompletableFuture<Stream<T>>>
  toFuture() {
    return new StreamOfFuturesCollector<>();
  }
}
```

This static factory method creates a new StreamOfFuturesCollector

End of Java CompletableFutures ImageStreamGang Example: StreamOfFuturesCollector