Overview of the ParallelFlowable Class

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Learning Objectives in this Part of the Lesson

- Understand the capabilities of the ParallelFlowable class

Class ParallelFlowable<T>

java.lang.Object
    io.reactivex.rxjava3.parallel.ParallelFlowable<T>

Type Parameters:
`T` - the value type

```
public abstract class ParallelFlowable<T>
extends Object
```

Abstract base class for parallel publishing of events signaled to an array of `Subscribers`.

Use `from(Publisher)` to start processing a regular `Publisher` in 'rails'. Use `runOn(Scheduler)` to introduce where each 'rail' should run on thread-vise. Use `sequential()` to merge the sources back into a single `Flowable`.

See reactivex.io/RxJava/3.x/javadoc/io/reactivex/rxjava3/parallel/ParallelFlowable.html

Learning Objectives in this Part of the Lesson

- Understand the capabilities of the ParallelFlowable class
  - Simplifies parallel processing *cf.* the flatMap() concurrency idiom


```
return Observable
   .fromArray(bigFractionArray)
   .flatMap(bf -> Observable
      .fromCallable(() -> bf
         .multiply(sBigFraction))
      .subscribeOn(Schedulers
                   .computation()))
   .reduce(BigFraction::add)...
```

```
return Flowable
   .fromArray(bigFractionArray)
   .parallel()
   .runOn(Schedulers.computation())
   .map(bf -> bf.multiply(sBigReducedFrac))
   .reduce(BigFraction::add)
   .firstElement()...
```

See earlier lesson on *"Key Transforming Operators in the Observable Class (Part 3)"*

Overview of the ParallelFlowable Class

Overview of the ParallelFlowable Class

- The RxJava flatMap() concurrency idiom performs relatively well, but is also somewhat convoluted..

```
return Observable
   .fromArray(bigFractionArray)

   .flatMap(bf -> Observable
      .fromCallable(() -> bf
         .multiply(sBigFraction))

      .subscribeOn(Schedulers
                   .computation()))

   .reduce(BigFraction::add)
   ...
```

Return an Observable that emits multiplied BigFraction objects via the RxJava flatMap() concurrency idiom

See previous lessons on *"Key Transforming Operators in the Observable Class (Part 3)"*

Overview of the ParallelFlowable Class

- The RxJava flatMap() concurrency idiom performs relatively well, but is also somewhat convoluted..
  - Particularly in comparison with Java parallel streams

```
return Stream
   .of(bigFractionArray)

   .parallel()

   .map(bf -> bf
        .multiply(sBigFraction))

   .reduce(ZERO, BigFraction::add)
```

```
return Observable
   .fromArray(bigFractionArray)

   .flatMap(bf -> Observable
      .fromCallable(() -> bf
           .multiply(sBigFraction))

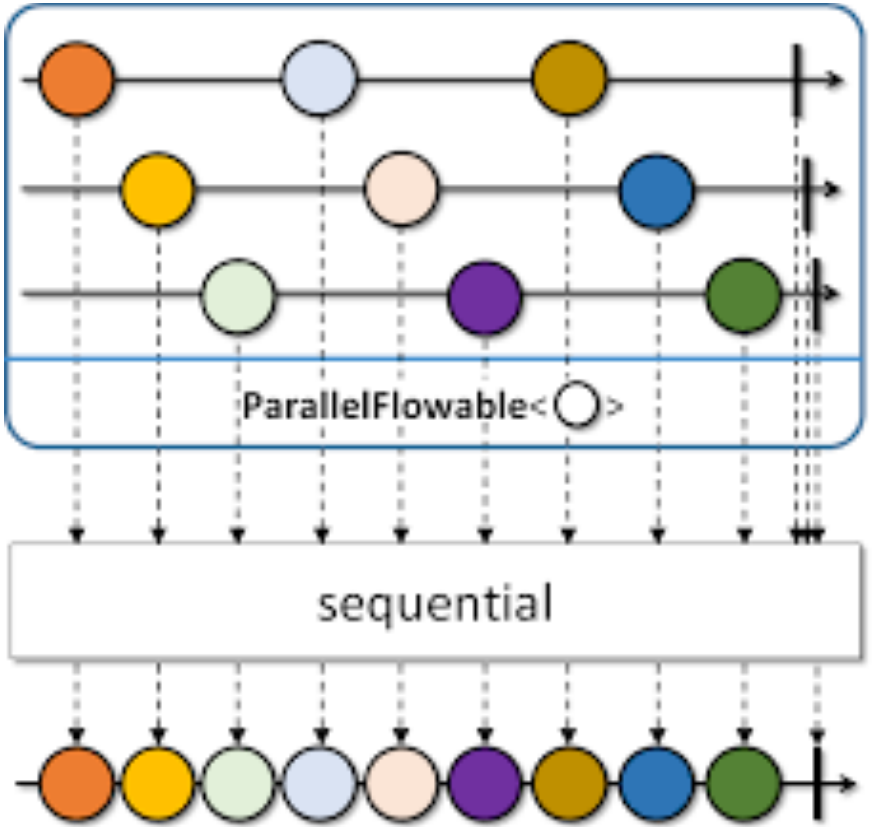
      .subscribeOn(Schedulers
                   .computation()))

   .reduce(BigFraction::add)
   ...
```

See docs.oracle.com/javase/tutorial/collections/streams/parallelism.html

Overview of the ParallelFlowable Class

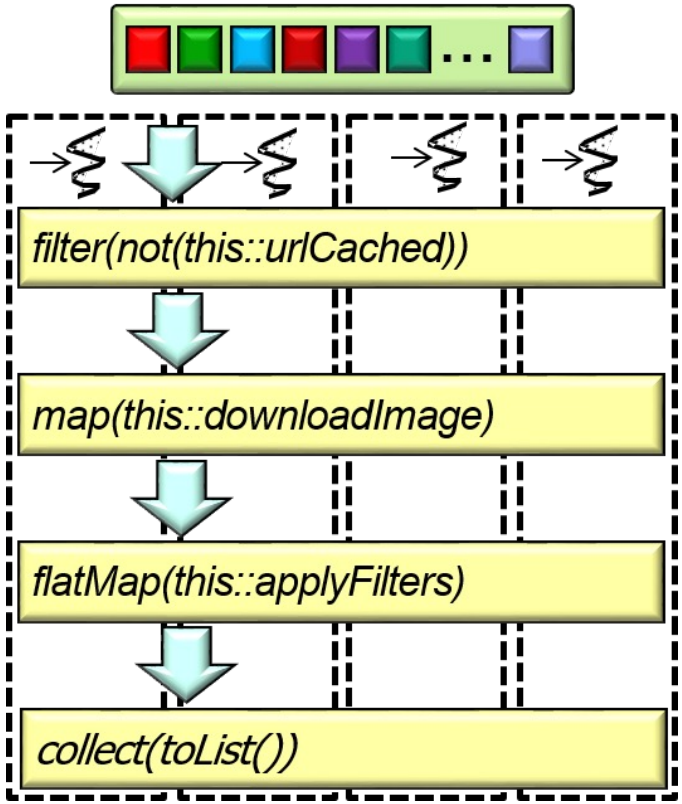
- ParallelFlowable is a subset of Flowable that provides a more concise means of processing multiple values in parallel



See reactivex.io/RxJava/3.x/javadoc/io/reactivex/rxjava3/parallel/ParallelFlowable.html

Overview of the ParallelFlowable Class

- ParallelFlowable is a subset of Flowable that provides a more concise means of processing multiple values in parallel
  - Similar to Java parallel streams



See dzone.com/articles/rxjava-idiomatic-concurrency-flatmap-vs-parallel

Overview of the ParallelFlowable Class

- ParallelFlowable is a subset of Flowable that provides a more concise means of processing multiple values in parallel
  - Similar to Java parallel streams
    - i.e., intended for "embarrassingly parallel" tasks

"Embarrassingly parallel" tasks have little/no dependency or need for communication between tasks or for sharing results between them

See en.wikipedia.org/wiki/Embarrassingly_parallel

Overview of the ParallelFlowable Class

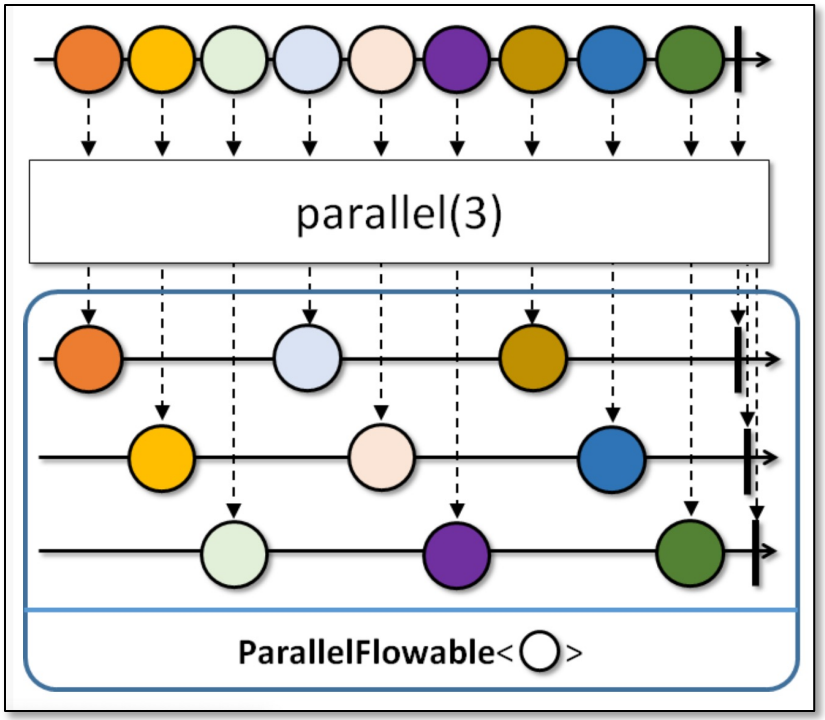
- ParallelFlowable is a subset of Flowable that provides a more concise means of processing multiple values in parallel
  - Similar to Java parallel streams
  - Avoids the convoluted syntax of the flatMap() concurrency idiom

See dzone.com/articles/rxjava-idiomatic-concurrency-flatmap-vs-parallel

Overview of the ParallelFlowable Class

- ParallelFlowable is a subset of Flowable that provides a more concise means of processing multiple values in parallel
  - Similar to Java parallel streams
  - Avoids the convoluted syntax of the flatMap() concurrency idiom
  - The Flowable.parallel() factory method creates a ParallelFlowable

```
ParallelFlowable<T> parallel()
```

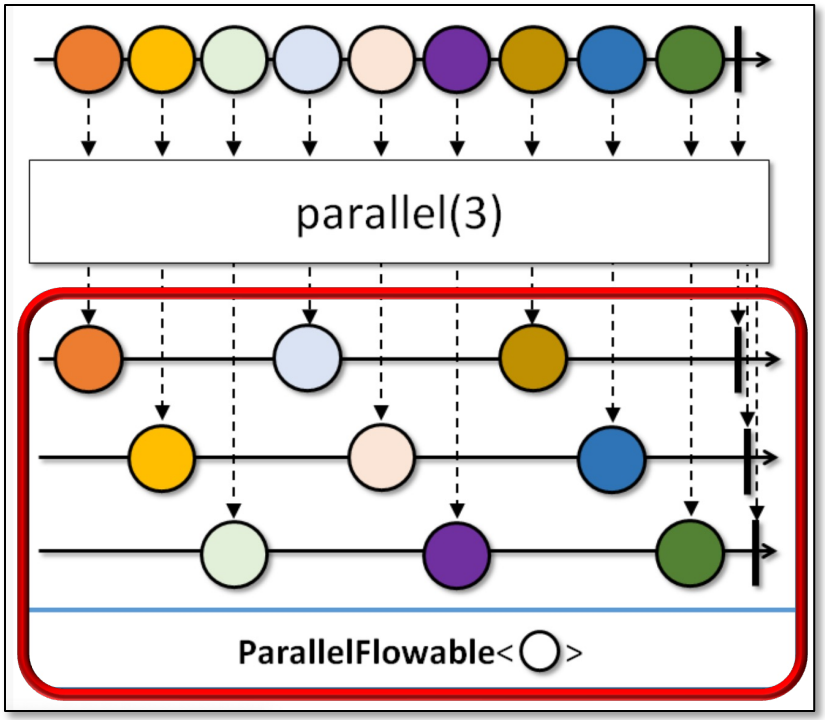


See reactivex.io/RxJava/3.x/javadoc/io/reactivex/rxjava3/core/Flowable.html#parallel

Overview of the ParallelFlowable Class

- ParallelFlowable is a subset of Flowable that provides a more concise means of processing multiple values in parallel
  - Similar to Java parallel streams
  - Avoids the convoluted syntax of the flatMap() concurrency idiom
  - The Flowable.parallel() factory method creates a ParallelFlowable
    - Elements are processed in parallel via 'rails' in round-robin order

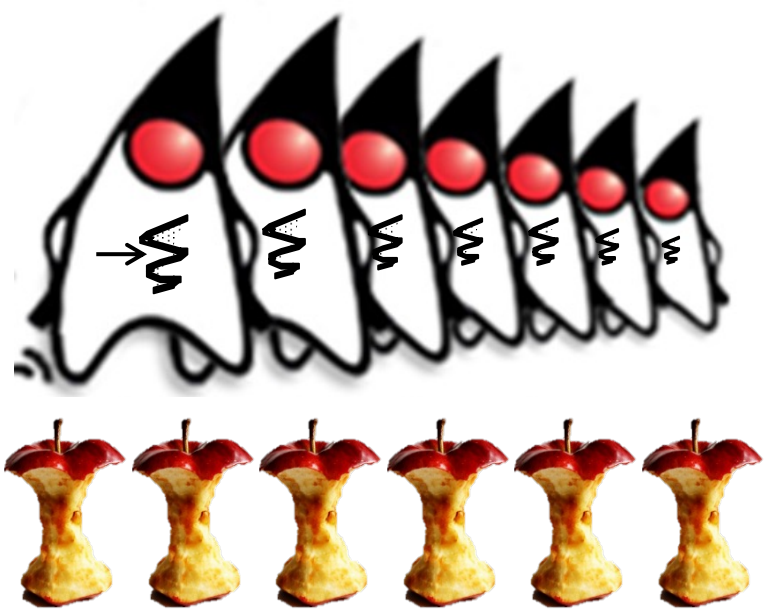
```
ParallelFlowable<T> parallel()
```



See reactivex.io/RxJava/3.x/javadoc/io/reactivex/rxjava3/core/Flowable.html#parallel

Overview of the ParallelFlowable Class

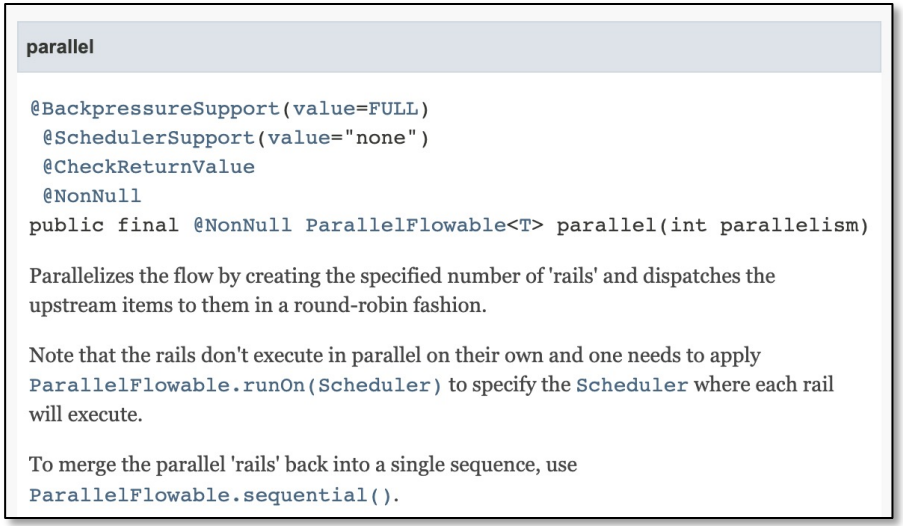
- ParallelFlowable is a subset of Flowable that provides a more concise means of processing multiple values in parallel
  - Similar to Java parallel streams
  - Avoids the convoluted syntax of the flatMap() concurrency idiom
  - The Flowable.parallel() factory method creates a ParallelFlowable
    - Elements are processed in parallel via 'rails' in round-robin order
    - By default, the # of rails is set to the # of available CPU cores



See docs.oracle.com/javase/8/docs/api/java/lang/Runtime.html#availableProcessors

Overview of the ParallelFlowable Class

- ParallelFlowable is a subset of Flowable that provides a more concise means of processing multiple values in parallel
  - Similar to Java parallel streams
  - Avoids the convoluted syntax of the flatMap() concurrency idiom
  - The Flowable.parallel() factory method creates a ParallelFlowable
    - Elements are processed in parallel via 'rails' in round-robin order
    - By default, the # of rails is set to the # of available CPU cores
      - This setting can be changed programmatically



parallel

```
@BackpressureSupport(value=FULL)
 @SchedulerSupport(value="none")
 @CheckReturnValue
 @NonNull
public final @NonNull ParallelFlowable<T> parallel(int parallelism)
```

Parallelizes the flow by creating the specified number of 'rails' and dispatches the upstream items to them in a round-robin fashion.

Note that the rails don't execute in parallel on their own and one needs to apply `ParallelFlowable.runOn(Scheduler)` to specify the `Scheduler` where each rail will execute.

To merge the parallel 'rails' back into a single sequence, use `ParallelFlowable.sequential()`.

See reactivex.io/RxJava/3.x/javadoc/io/reactivex/rxjava3/core/Flowable.html#parallel

Overview of the ParallelFlowable Class

- ParallelFlowable supports a subset of Flowable operators that process elements in parallel across the rails
  - e.g., map(), filter(), concatMap(), flatMap(), collect(), & reduce()

See github.com/ReactiveX/RxJava/wiki/Parallel-flows

Overview of the ParallelFlowable Class

- The runOn() operator specifies where each 'rail' will observe its incoming elements

```
ParallelFlowable<T> runOn(Scheduler
                          scheduler)
```

See reactivex.io/RxJava/3.x/javadoc/io/reactivex/rxjava3/parallel/ParallelFlowable.html#runOn

Overview of the ParallelFlowable Class

- The runOn() operator specifies where each 'rail' will observe its incoming elements
  - Specified via a Scheduler that performs no work-stealing

```
ParallelFlowable<T> runOn(Scheduler
                          scheduler)
```

See reactivex.io/RxJava/3.x/javadoc/io/reactivex/rxjava3/schedulers/Schedulers.html

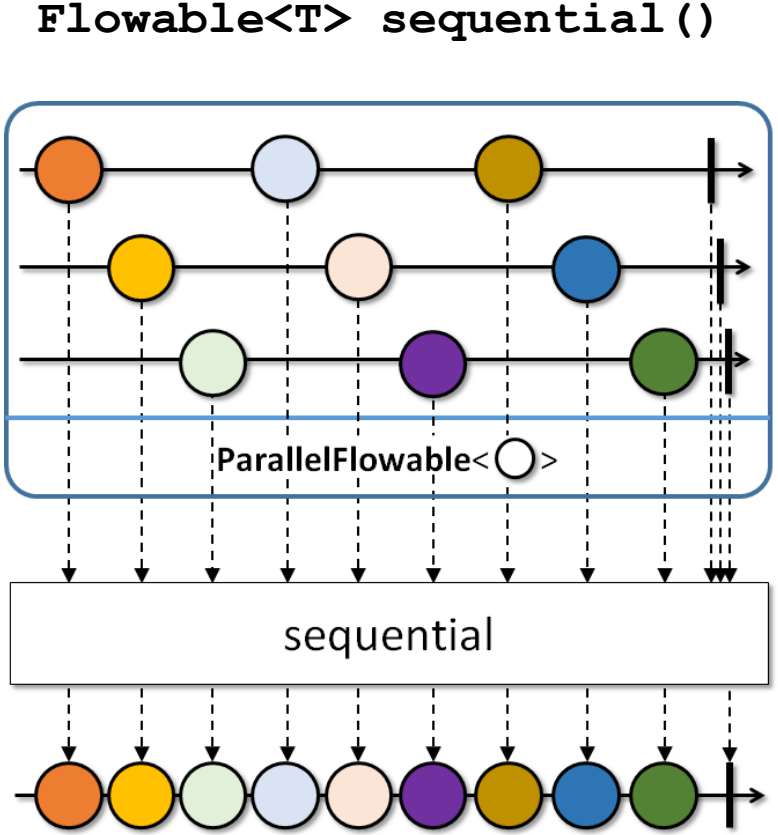
Overview of the ParallelFlowable Class

- The runOn() operator specifies where each 'rail' will observe its incoming elements
  - Specified via a Scheduler that performs no work-stealing
  - Returns the new Parallel Flowable instance

```
ParallelFlowable<T> runOn(Scheduler
                          scheduler)
```

Overview of the ParallelFlowable Class

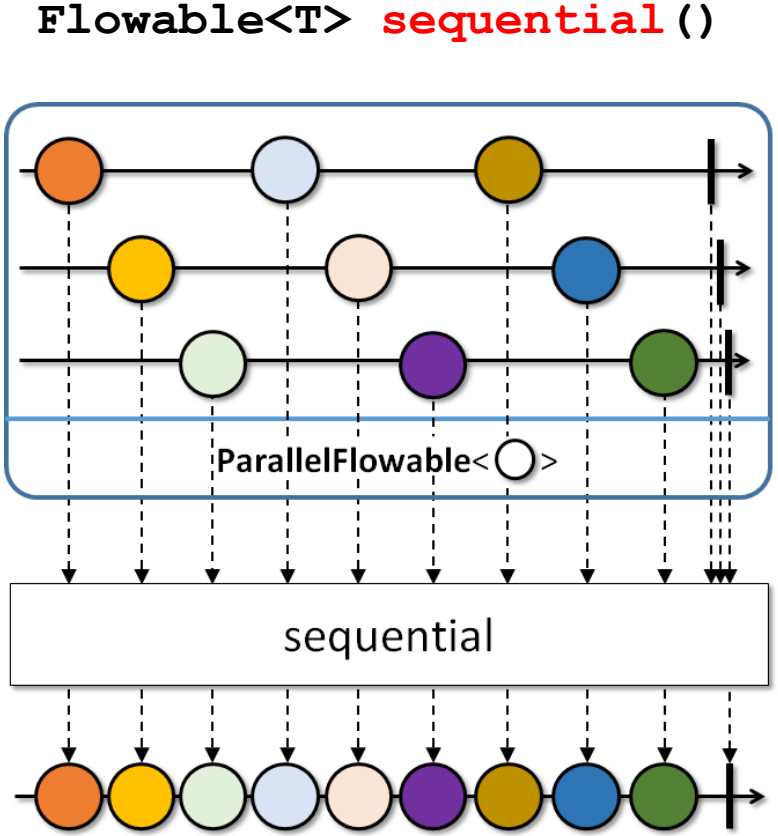
- A ParallelFlowable can be converted back into a Flowable via sequential()



See reactivex.io/RxJava/3.x/javadoc/io/reactivex/rxjava3/parallel/ParallelFlowable.html#sequential

Overview of the ParallelFlowable Class

- A ParallelFlowable can be converted back into a Flowable via sequential()
  - Merge the values from each 'rail' in a round-robin fashion



See reactivex.io/RxJava/3.x/javadoc/io/reactivex/rxjava3/parallel/ParallelFlowable.html#sequential

Overview of the ParallelFlowable Class

- ParallelFlowable.reduce() can also be used to convert back into a Flowable

reduce

```
@CheckReturnValue
 @NonNull
 @BackpressureSupport(value=UNBOUNDED_IN)
 @SchedulerSupport(value="none")
public final @NonNull Flowable<T> reduce(@NonNull BiFunction<T,T,T> reducer)
```

Reduces all values within a 'rail' and across 'rails' with a reducer function into one `Flowable` sequence.

Note that the same reducer function may be called from multiple threads concurrently.

Backpressure:
The operator honors backpressure from the downstream and consumes the upstream rails in an unbounded manner (requesting `Long.MAX_VALUE`).

Scheduler:
`reduce` does not operate by default on a particular `Scheduler`.

Parameters:
`reducer` - the function to reduce two values into one.

Returns:
the new `Flowable` instance emitting the reduced value or empty if the current `ParallelFlowable` is empty

Throws:
`NullPointerException` - if `reducer` is `null`

See reactivex.io/RxJava/3.x/javadoc/io/reactivex/rxjava3/parallel/ParallelFlowable.html#reduce

Overview of the ParallelFlowable Class

- ParallelFlowable.reduce() can also be used to convert back into a Flowable
  - Reduces all values within a 'rail' & across 'rails' into a Flowable

```
Flowable<T> reduce
   (BiFunction<T,T,T> reducer)
```

See reactivex.io/RxJava/3.x/javadoc/io/reactivex/rxjava3/parallel/ParallelFlowable.html#reduce

Overview of the ParallelFlowable Class

- ParallelFlowable.reduce() can also be used to convert back into a Flowable
  - Reduces all values within a 'rail' & across 'rails' into a Flowable
  - The BiFunction param reduces two values into one successively

```
Flowable<T> reduce
   (BiFunction<T,T,T> reducer)
```

See reactivex.io/RxJava/3.x/javadoc/io/reactivex/rxjava3/functions/BiFunction.html

Overview of the ParallelFlowable Class

- ParallelFlowable.reduce() can also be used to convert back into a Flowable
  - Reduces all values within a 'rail' & across 'rails' into a Flowable
  - The BiFunction param reduces two values into one successively
  - Return a regular Flowable that contains just one element

```
Flowable<T> reduce
   (BiFunction<T,T,T> reducer)
```

Overview of the ParallelFlowable Class

- Elements that flow through a ParallelFlowable stream are processed in parallel

Multiply BigFraction objects in parallel using RxJava's ParallelFlowable operators

```
return Flowable
   .fromArray(bigFractionArray)
   .parallel()
   .runOn
      (Schedulers.computation())
   .map(bf -> bf
        .multiply(sBigReducedFrac))
   .reduce(BigFraction::add)
   .firstElement()
   .doOnSuccess(displayResults)
```

See github.com/douglascraigschmidt/LiveLessons/tree/master/Reactive/Flowable/ex3

Overview of the ParallelFlowable Class

- Elements that flow through a ParallelFlowable stream are processed in parallel

Convert an array into a Flowable

```
return Flowable
   .fromArray(bigFractionArray)
   .parallel()
   .runOn
      (Schedulers.computation())
   .map(bf -> bf
        .multiply(sBigReducedFrac))
   .reduce(BigFraction::add)
   .firstElement()
   .doOnSuccess(displayResults)
```

Overview of the ParallelFlowable Class

- Elements that flow through a ParallelFlowable stream are processed in parallel

Convert the Flowable into a ParallelFlowable

```
return Flowable
   .fromArray(bigFractionArray)
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```

Overview of the ParallelFlowable Class

- Elements that flow through a ParallelFlowable stream are processed in parallel

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   .fromArray(bigFractionArray)
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      (Schedulers.computation())
   .map(bf -> bf
        .multiply(sBigReducedFrac))
   .reduce(BigFraction::add)
   .firstElement()
   .doOnSuccess(displayResults)
```

Designate the computation Scheduler that multiplies each image in parallel

See reactivex.io/RxJava/3.x/javadoc/io/reactivex/rxjava3/parallel/ParallelFlowable.html#runOn

Overview of the ParallelFlowable Class

- Elements that flow through a ParallelFlowable stream are processed in parallel

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   .runOn
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   .map(bf -> bf
         .multiply(sBigReducedFrac))
   .reduce(BigFraction::add)
   .firstElement()
   .doOnSuccess(displayResults)
```

Multiply BigFraction objects in parallel using map()

Overview of the ParallelFlowable Class

- Elements that flow through a ParallelFlowable stream are processed in parallel

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return Flowable
   .fromArray(bigFractionArray)
   .parallel()
   .runOn
      (Schedulers.computation())
   .map(bf -> bf
        .multiply(sBigReducedFrac))
   .reduce(BigFraction::add)
   .firstElement()
   .doOnSuccess(displayResults)
```

Reduce all values within a 'rail' & across 'rails' via BigFraction::add into a Flowable sequence with one element

Overview of the ParallelFlowable Class

- Elements that flow through a ParallelFlowable stream are processed in parallel

```
return Flowable
   .fromArray(bigFractionArray)
   .parallel()
   .runOn
      (Schedulers.computation())
   .map(bf -> bf
        .multiply(sBigReducedFrac))
   .reduce(BigFraction::add)
   .firstElement()
   .doOnSuccess(displayResults)
```

Return a Maybe that emits the one & only element in the Flowable

Overview of the ParallelFlowable Class

- Elements that flow through a ParallelFlowable stream are processed in parallel

```
return Flowable
   .fromArray(bigFractionArray)
   .parallel()
   .runOn
      (Schedulers.computation())
   .map(bf -> bf
        .multiply(sBigReducedFrac))
   .reduce(BigFraction::add)
   .firstElement()
   .doOnSuccess(displayResults)
```

Display the results if all goes well

End of Overview of the ParallelFlowable Class