

The History of Concurrency & Parallelism

Support in Java

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Learning Objectives in this Part of the Lesson

- Be aware of the history of Java concurrency & parallelism



Java/JNI

Applications

Additional Frameworks & Languages

Threading & Synchronization Packages

C++/C

Java Execution Environment (e.g., JVM)

System Libraries

C

Operating System Kernel

Learning Objectives in this Part of the Lesson

- Be aware of the history of Java concurrency & parallelism

~~UNKNOWN~~



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Hopefully, you'll already know some of this!!!

A Brief History of Concurrency in Java

A Brief History of Concurrency in Java

- Foundational concurrency support

e.g., Java threads & built-in monitor objects available in Java 1

Java/JNI

C++/C

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Applications

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Threading & Synchronization Packages

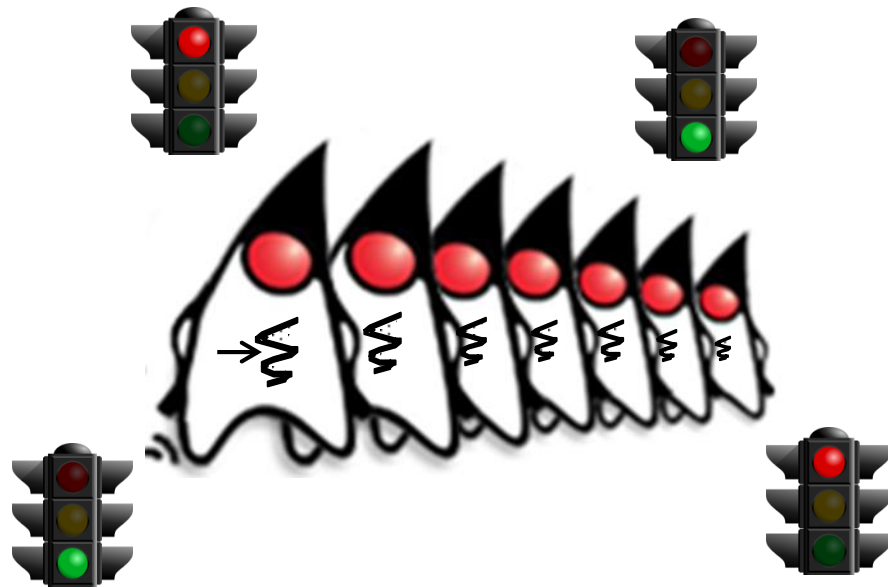
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A Brief History of Concurrency in Java

- Foundational concurrency support
 - Focus on basic multi-threading & synchronization primitives



See docs.oracle.com/javase/tutorial/essential/concurrency

A Brief History of Concurrency in Java

- Foundational concurrency support
 - Focus on basic multi-threading & synchronization primitives

*Allow multiple threads
to communicate via a
bounded buffer*

```
SimpleBlockingBoundedQueue<Integer>  
simpleQueue = new  
SimpleBlockingBoundedQueue<>();
```

```
Thread[] threads = new Thread[] {  
    new Thread(new Producer<>  
                (simpleQueue)),  
    new Thread(new Consumer<>  
                (simpleQueue))  
};
```

```
for (Thread thread : threads)  
    thread.start();
```

```
for (Thread thread : threads)  
    thread.join();
```


A Brief History of Concurrency in Java

- Foundational concurrency support
 - Focus on basic multi-threading & synchronization primitives

```
SimpleBlockingBoundedQueue<Integer>  
simpleQueue = new  
SimpleBlockingBoundedQueue<>();
```

```
Thread[] threads = new Thread[] {  
    new Thread(new Producer<>  
                (simpleQueue)),  
    new Thread(new Consumer<>  
                (simpleQueue))  
};
```

*Start & join these
multiple threads*



```
for (Thread thread : threads)  
    thread.start();
```

```
for (Thread thread : threads)  
    thread.join();
```


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- Foundational concurrency support
- Focus on basic multi-threading & synchronization primitives

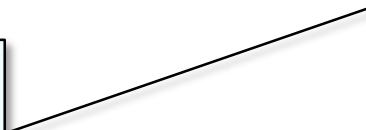
```
class SimpleBlockingBoundedQueue
    <E> {

    public E take() ...{
        synchronized(this) {
            while (mList.isEmpty())
                wait();

            notifyAll();

            return mList.poll();
        }
    }
}
```

*Built-in monitor object
mutual exclusion &
coordination primitives*



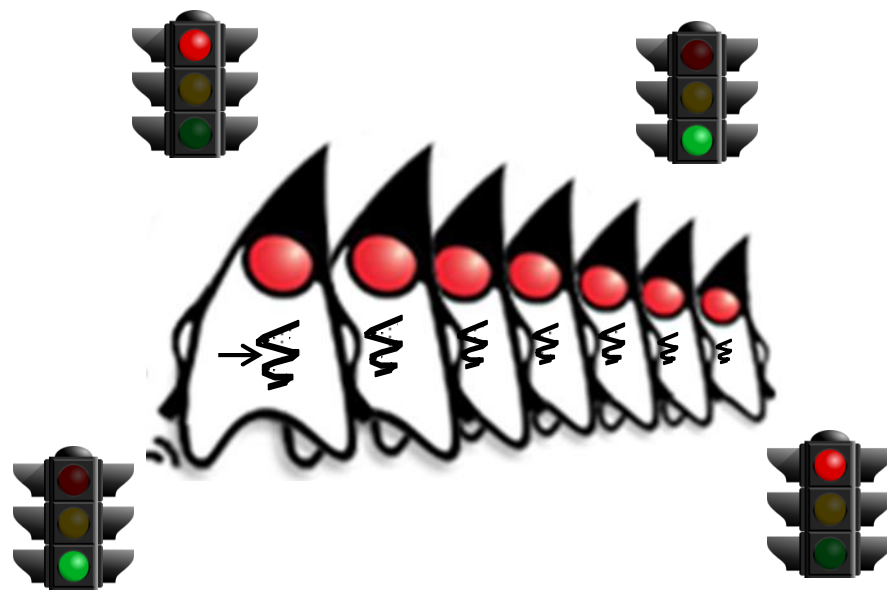
A Brief History of Concurrency in Java

- Foundational concurrency support
 - Focus on basic multi-threading & synchronization primitives
 - Efficient, but low-level & very limited in capabilities



A Brief History of Concurrency in Java

- Foundational concurrency support
 - Focus on basic multi-threading & synchronization primitives
 - Efficient, but low-level & very limited in capabilities
 - Many accidental complexities



Accidental complexities arise from limitations with software techniques, tools, & methods

See en.wikipedia.org/wiki/No_Silver_Bullet

A Brief History of Concurrency in Java

- Advanced concurrency support

e.g., Java executor framework, synchronizers, blocking queues, atomics, & concurrent collections available in Java 5+

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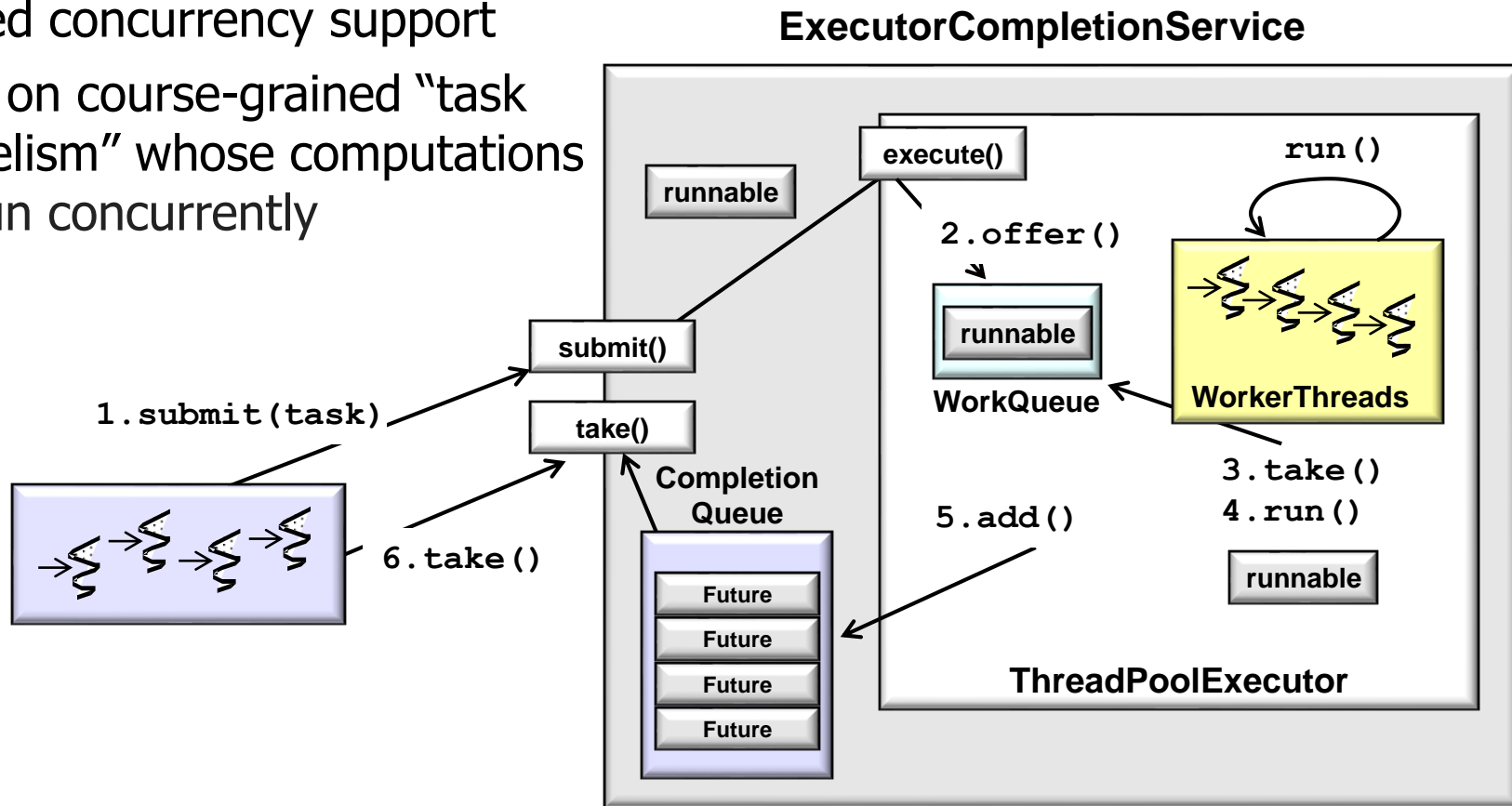
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A Brief History of Concurrency in Java

- Advanced concurrency support
- Focus on course-grained “task parallelism” whose computations can run concurrently



See en.wikipedia.org/wiki/Task_parallelism

A Brief History of Concurrency in Java

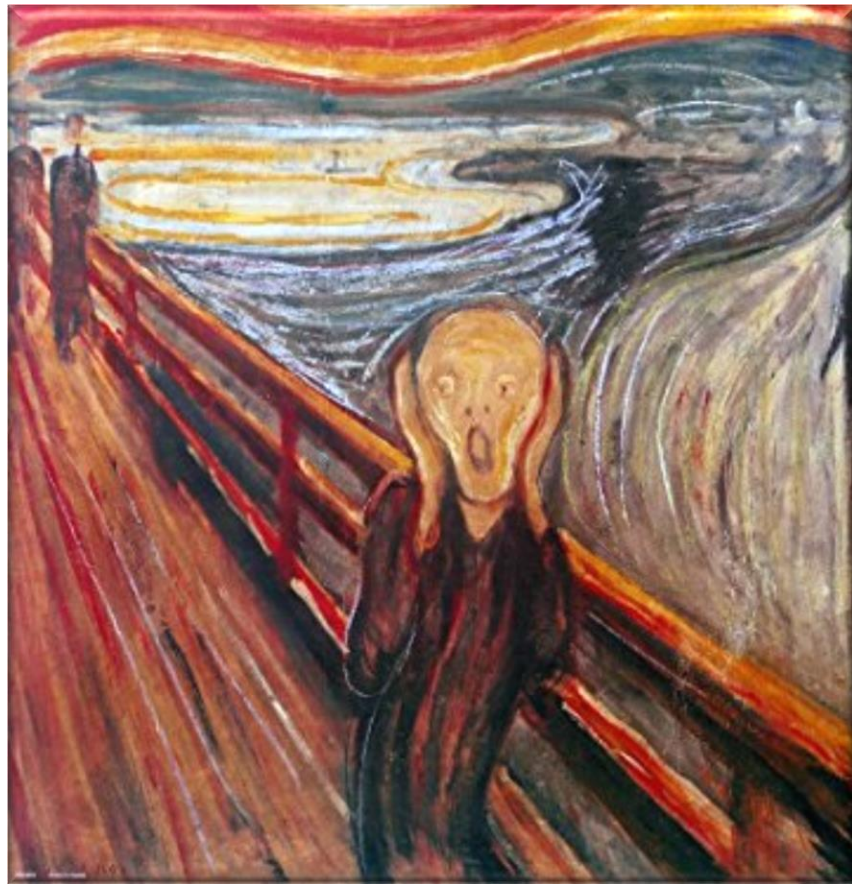
- Advanced concurrency support
 - Focus on course-grained “task parallelism” whose computations can run concurrently

*Create a fixed-sized thread pool
& also coordinate the starting &
stopping of multiple tasks that
acquire/release shared resources*

```
ExecutorService executor =  
    Executors.newFixedThreadPool  
        (numOfBeings,  
         mThreadFactory) ;  
...  
CyclicBarrier entryBarrier =  
    new CyclicBarrier(numOfBeings+1) ;  
  
CountDownLatch exitBarrier =  
    new CountDownLatch(numOfBeings) ;  
  
for (int i=0; i < beingCount; ++i)  
    executor.execute  
        (makeBeingRunnable(i,  
                             entryBarrier,  
                             exitBarrier)) ;
```

A Brief History of Concurrency in Java

- Advanced concurrency support
 - Focus on course-grained “task parallelism” whose computations can run concurrently
 - Feature-rich & optimized, but also tedious & error-prone to program



A Brief History of Parallelism in Java

A Brief History of Parallelism in Java

- Foundational parallelism support

*e.g., Java fork-join pool
made available in Java 7*

Java/JNI

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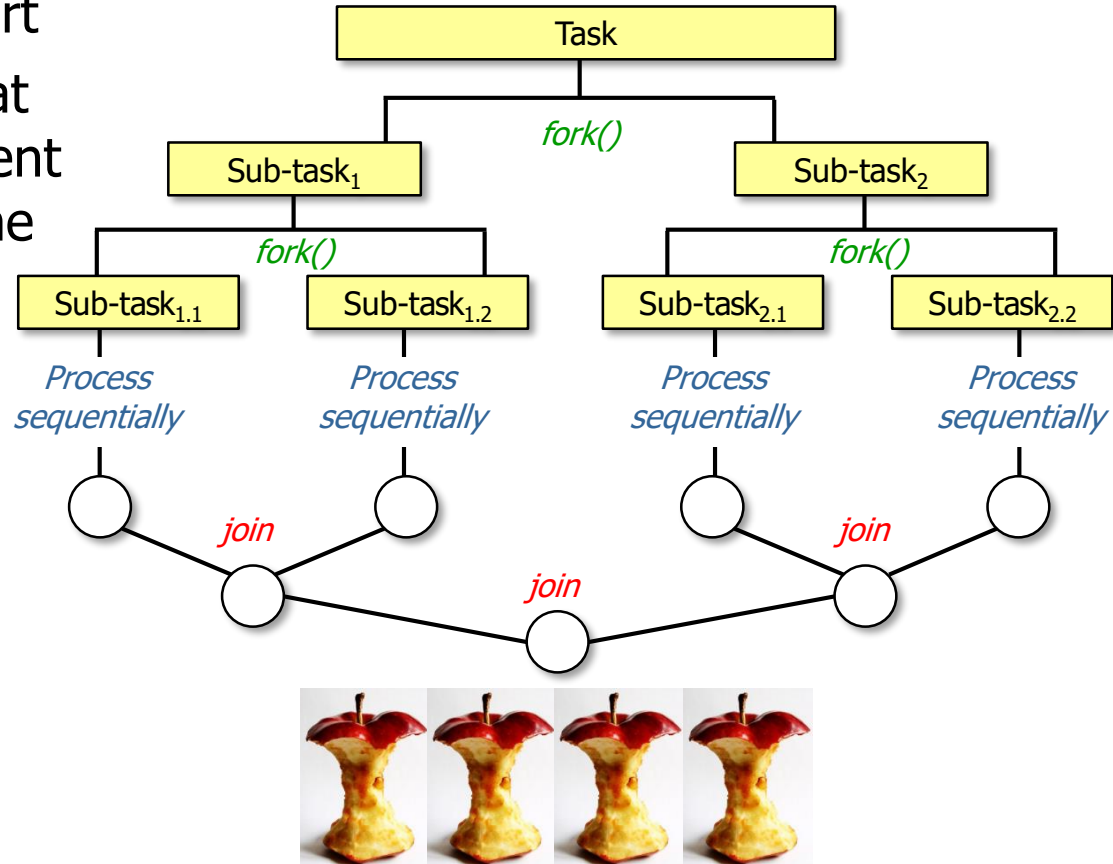
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A Brief History of Parallelism in Java

- Foundational parallelism support
 - Focus on data parallelism that runs the same task on different data elements by applying the split-apply-combine model



See en.wikipedia.org/wiki/Data_parallelism

A Brief History of Parallelism in Java

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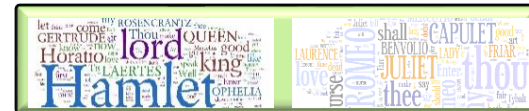
```
List<List<SearchResults>>  
listOfListOfSearchResults =  
    ForkJoinPool  
        .commonPool()  
        .invoke(new  
            SearchWithForkJoinTask  
                (inputList,  
                 mPhrasesToFind, ...));
```

*Use a common fork-join pool
to search input strings to
locate phrases that match*

Input Strings to Search

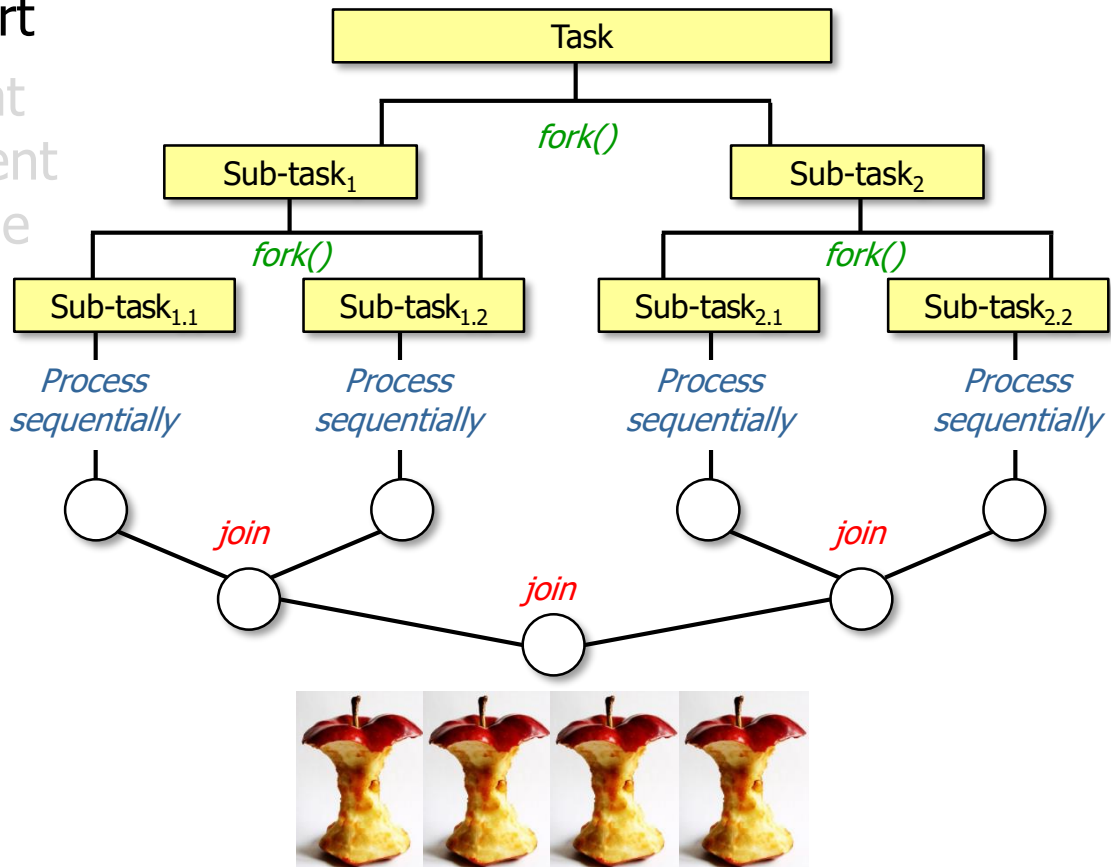
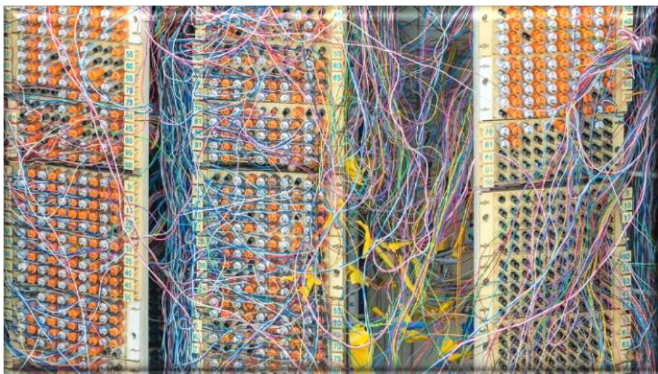


Search Phrases



A Brief History of Parallelism in Java

- Foundational parallelism support
 - Focus on data parallelism that runs the same task on different data elements by applying the split-apply-combine model
- Powerful & scalable, but tedious to program directly



A Brief History of Parallelism in Java

- Advanced parallelism support

*e.g., Java parallel streams
& completable futures
made available in Java 8*

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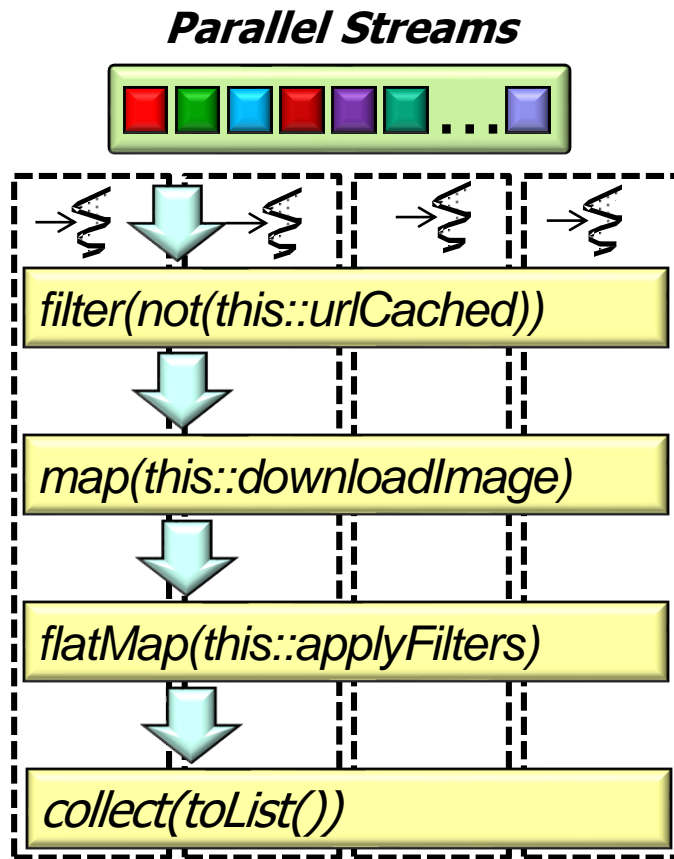
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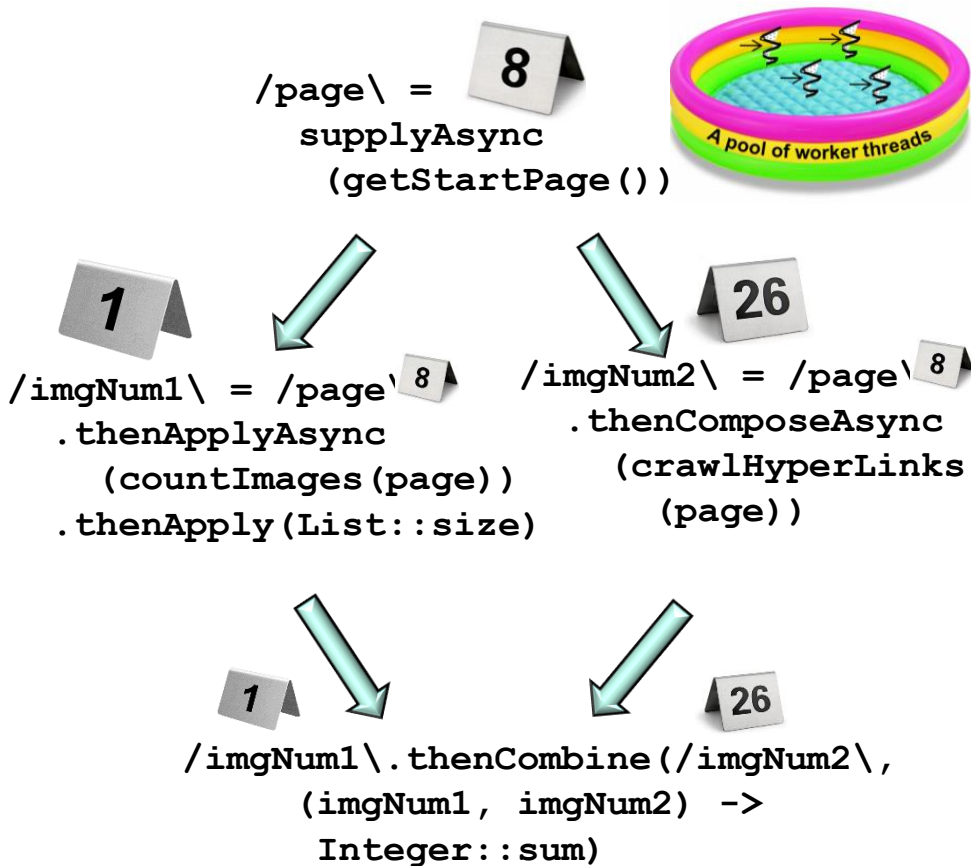
- Advanced parallelism support
 - Focus on functional programming for **data parallelism**



See en.wikipedia.org/wiki/Data_parallelism

A Brief History of Parallelism in Java

- Advanced parallelism support
 - Focus on functional programming for data parallelism & **reactive asynchrony**

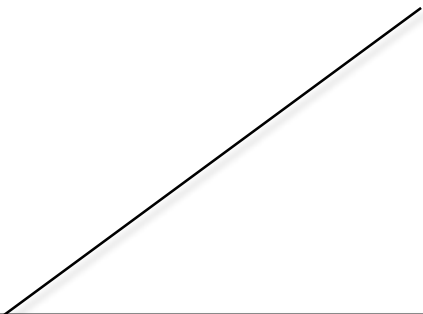


See gist.github.com/staltz/868e7e9bc2a7b8c1f754

A Brief History of Parallelism in Java

- Advanced parallelism support
- Focus on functional programming for **data parallelism** & reactive asynchrony

```
List<Image> images =  
    urls  
        .parallelStream()  
        .filter(not(this::urlCached))  
        .map(this::downloadImage)  
        .flatMap(this::applyFilters)  
        .collect(toList());
```



Synchronously download images that aren't already cached from a list of URLs & process/store the images in parallel

A Brief History of Parallelism in Java

- Advanced parallelism support
 - Focus on functional programming for data parallelism & **reactive asynchrony**

Asynchronously download images that aren't already cached from a list of URLs & process/store the images in parallel

```
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();
```

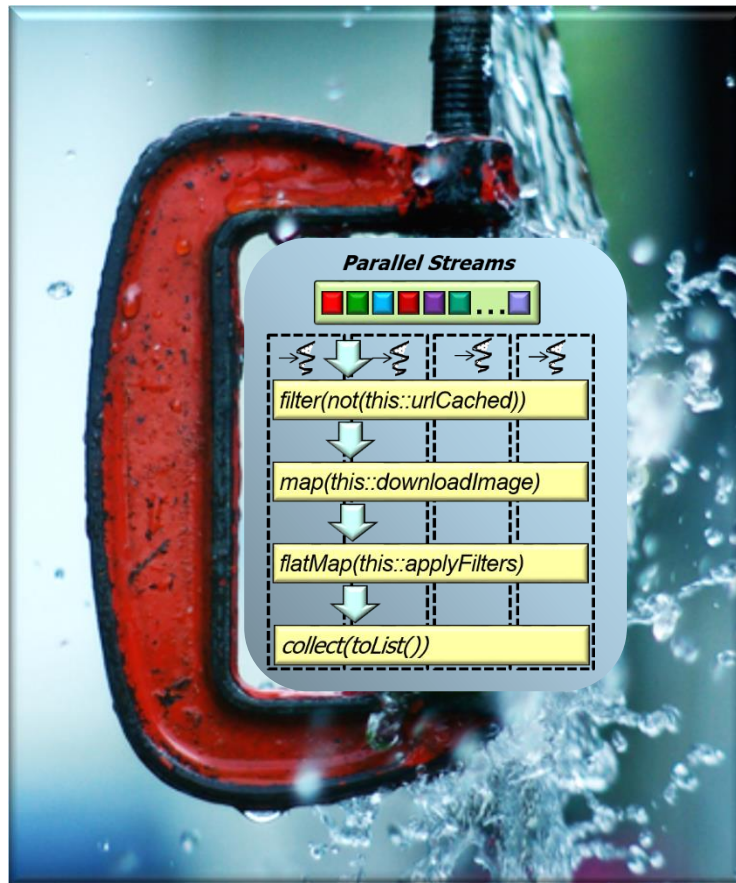
A Brief History of Parallelism in Java

- Advanced parallelism support
 - Focus on functional programming for data parallelism & reactive asynchrony
- Strikes an effective balance between productivity & performance



A Brief History of Parallelism in Java

- Advanced parallelism support
 - Focus on functional programming for data parallelism & reactive asynchrony
 - Strikes an effective balance between productivity & performance
- However, may be overly prescriptive



End of History of Concurrency & Parallelism in Java