The History of Concurrency & Parallelism Support in Java

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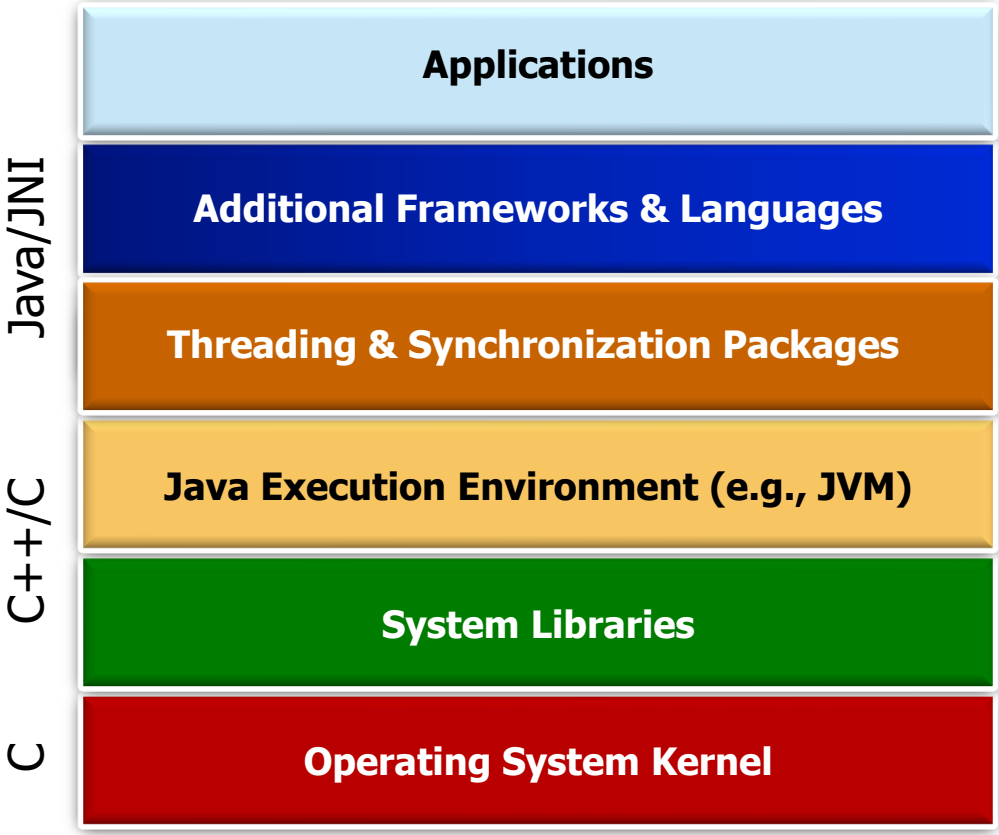
Learning Objectives in this Part of the Lesson

- Be aware of the history of Java concurrency & parallelism



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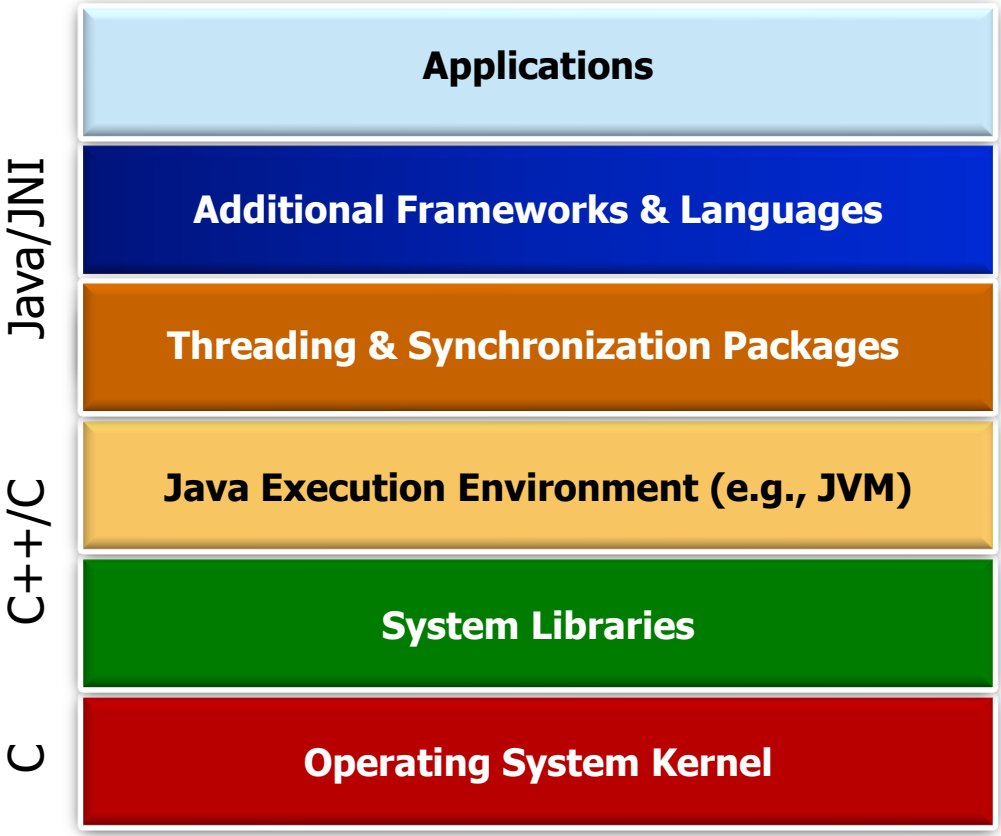
- Be aware of the history of Java concurrency & parallelism

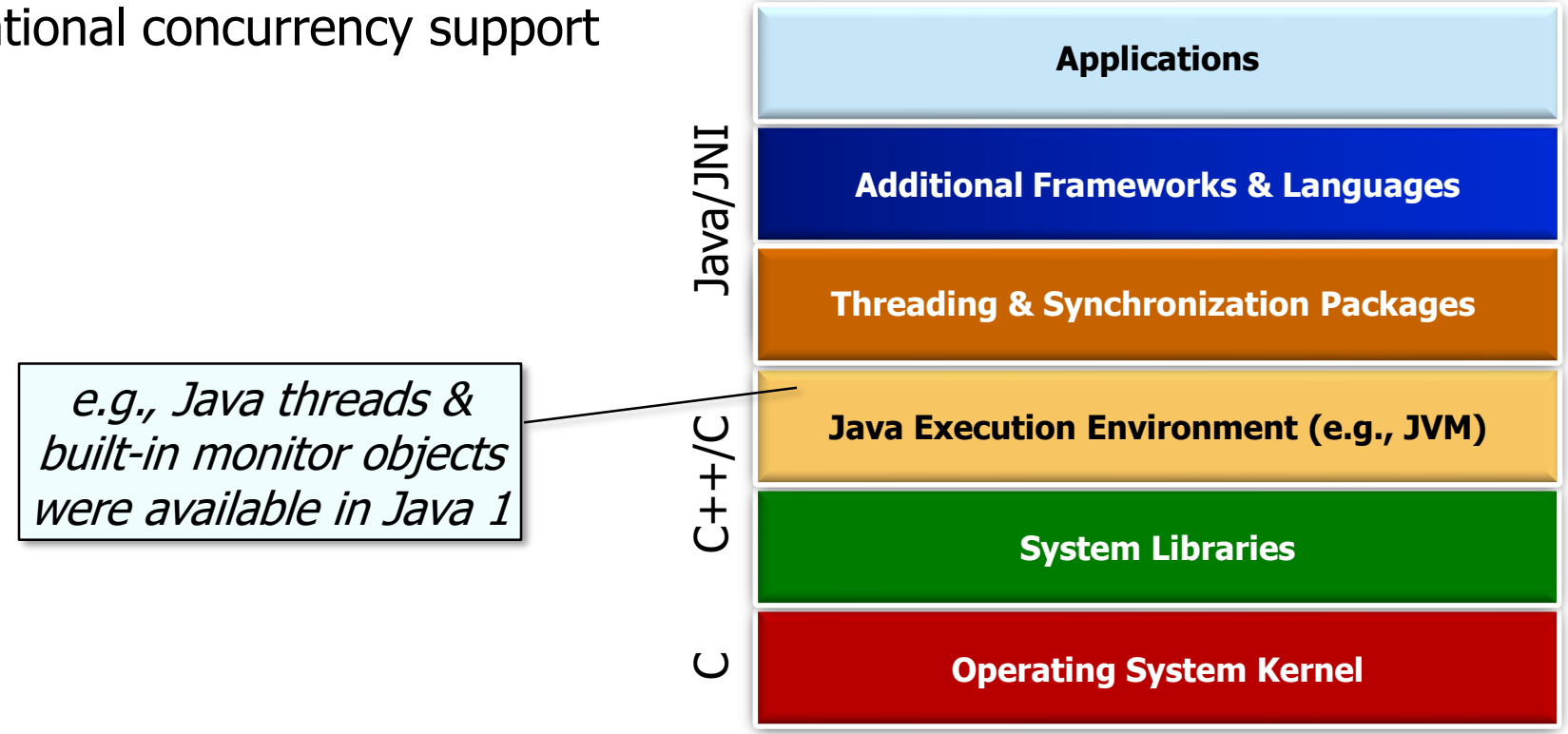


Hopefully, you'll already know some of this!!!

A Brief History of Concurrency in Java

A Brief History of Concurrency in Java

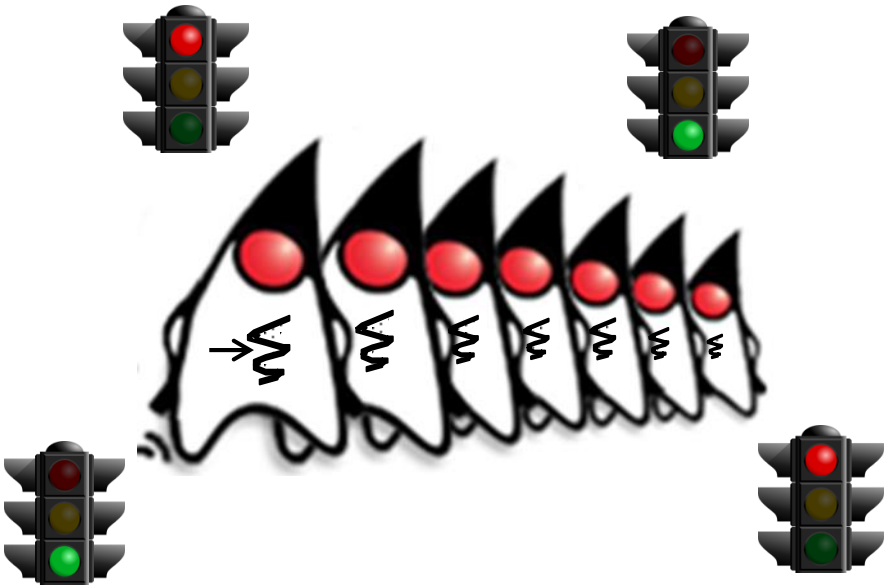
- Foundational concurrency support



See en.wikipedia.org/wiki/Java_version_history#JDK_1.0

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();
```

See github.com/douglascraigschmidt/LiveLessons/tree/master/SimpleBlockingQueue

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Start & join these multiple threads

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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

See github.com/douglascraigschmidt/LiveLessons/tree/master/SimpleBlockingQueue

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  - Efficient, but low-level & very limited in capabilities

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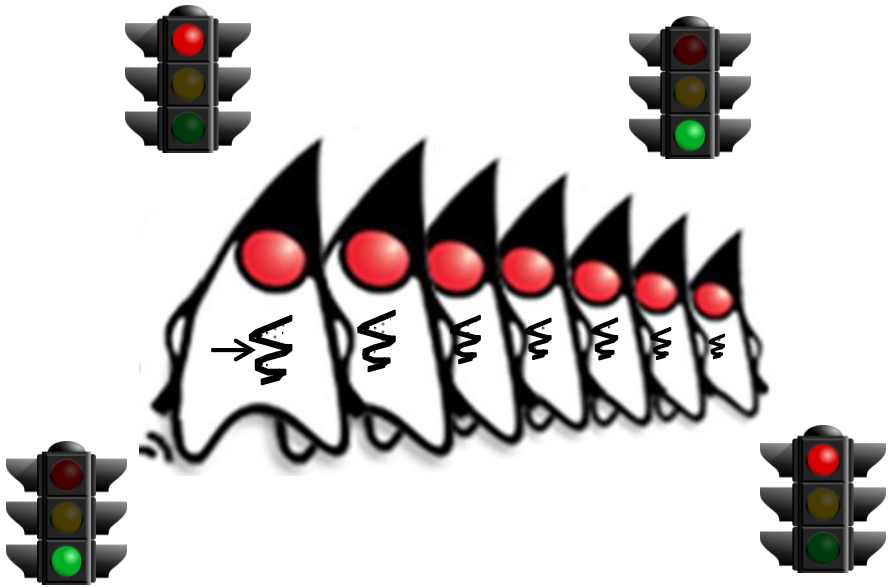
- Foundational concurrency support
  - Focus on basic multi-threading & synchronization primitives
  - Efficient, but low-level & very limited in capabilities
    - Many accidental complexities

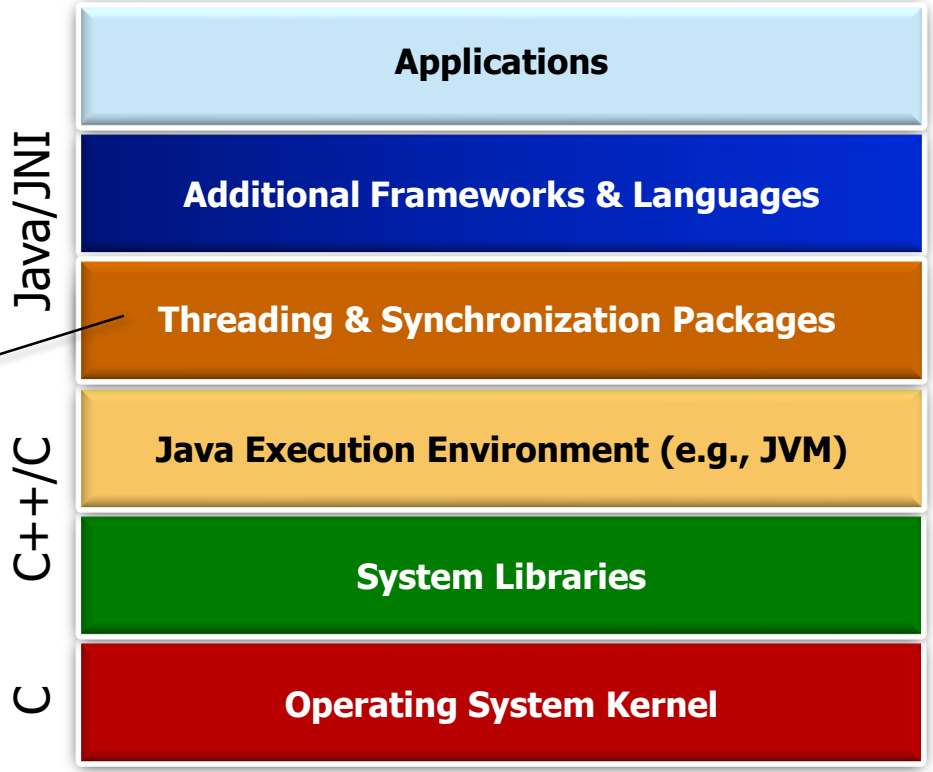


Accidental complexities arise from limitations with software techniques, tools, & methods

See en.wikipedia.org/wiki/No_Silver_Bullet

A Brief History of Concurrency in Java

- Advanced concurrency support

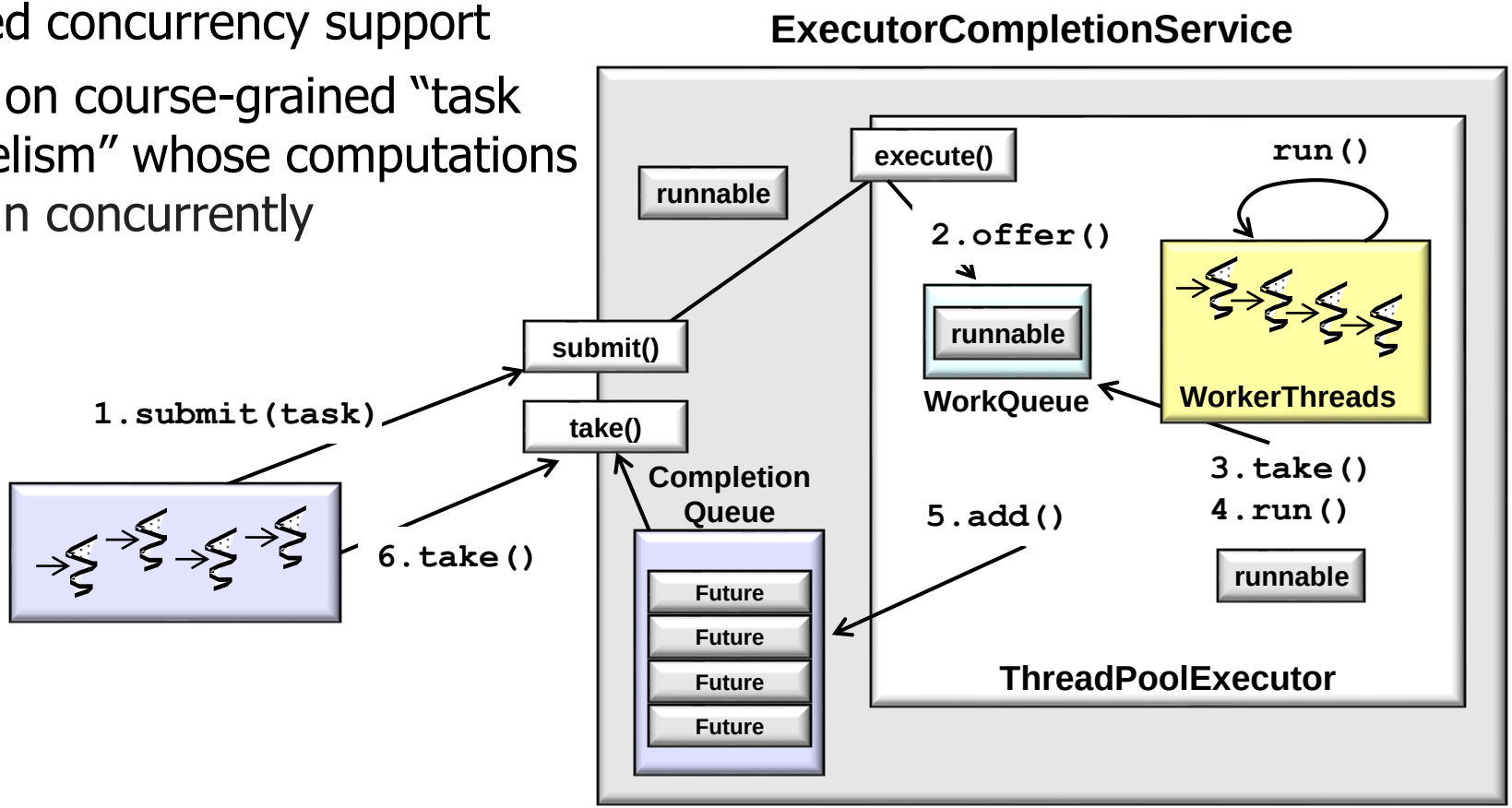


e.g., Java executor framework, synchronizers, blocking queues, atomics, & concurrent collections available in Java 5+

See en.wikipedia.org/wiki/Java_version_history#J2SE_5.0

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

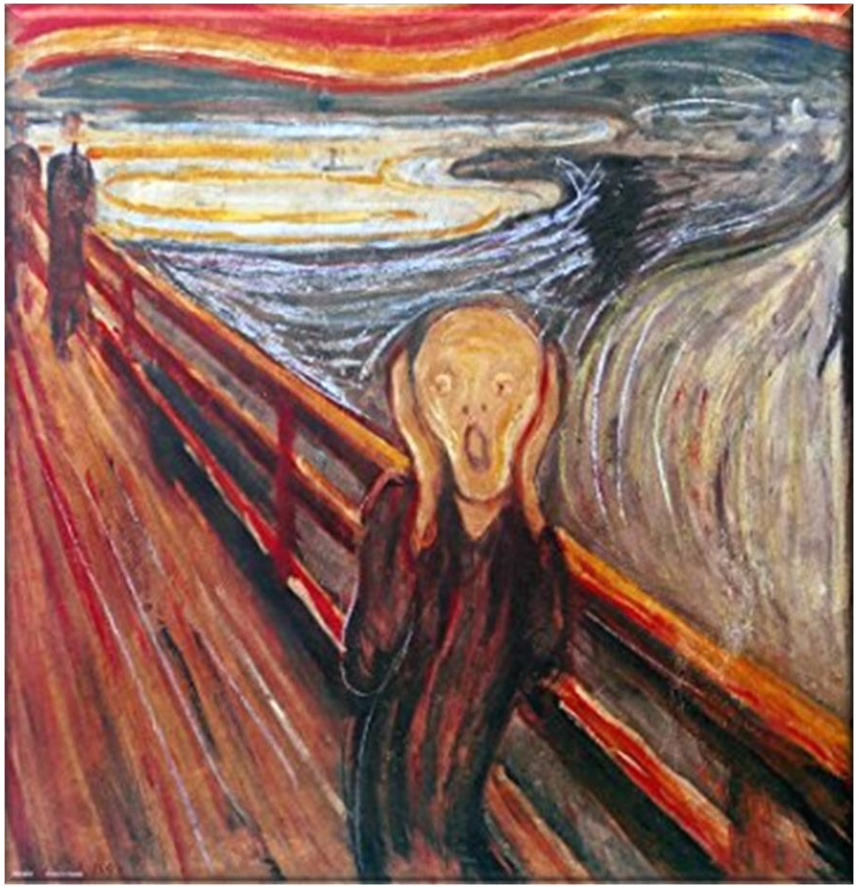
```
ExecutorService executor =
  Executors.newFixedThreadPool
    (numOfBeings,
     mThreadFactory);
...
CyclicBarrier entryBarrier =
  new CyclicBarrier(numOfBeings+1);

CountDownLatch exitBarrier =
  new CountDownLatch(numOfBeings);

for (int i=0; i < beingCount; ++i)
  executor.execute
    (makeBeingRunnable(i,
     entryBarrier,
     exitBarrier));
```

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

See github.com/douglascraigschmidt/LiveLessons/tree/master/PalantiriManagerApplication

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

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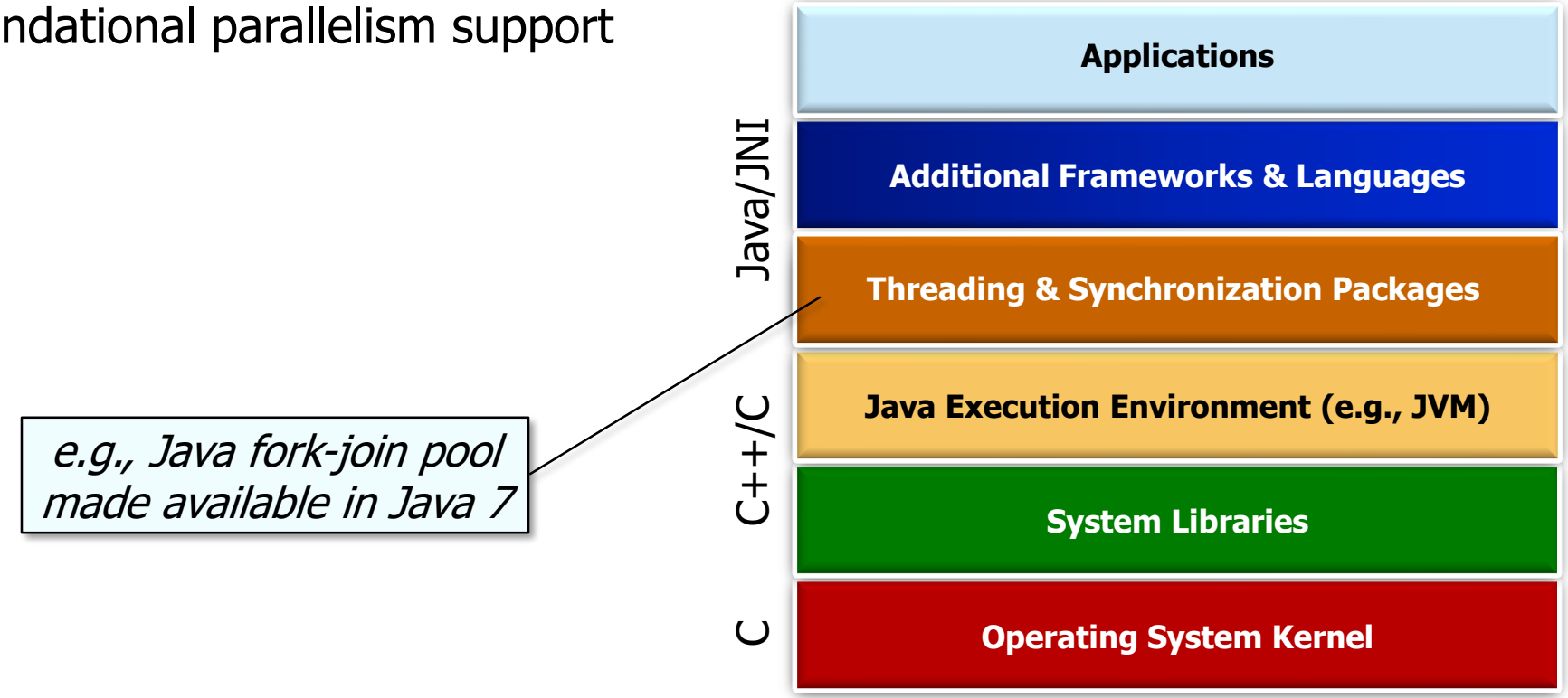
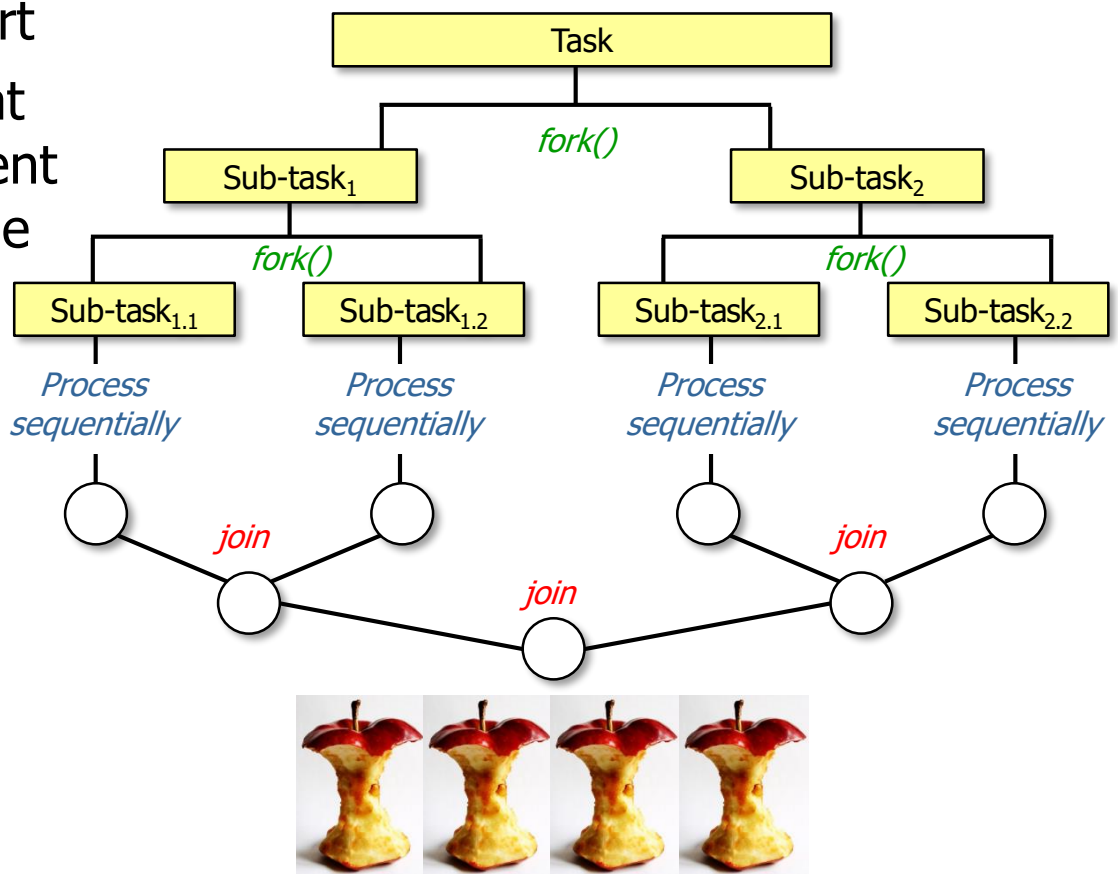
- Foundational parallelism support



See en.wikipedia.org/wiki/Java_version_history#Java_SE_7

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

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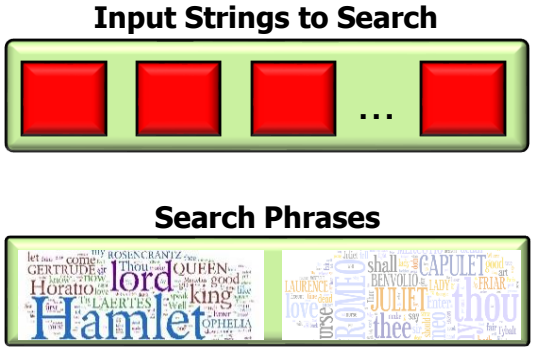
```
List<List<SearchResults>>
  listOfListOfSearchResults =
    ForkJoinPool
      .commonPool()
      .invoke(new
        SearchWithForkJoinTask
          (inputList,
           mPhrasesToFind, ...));
```

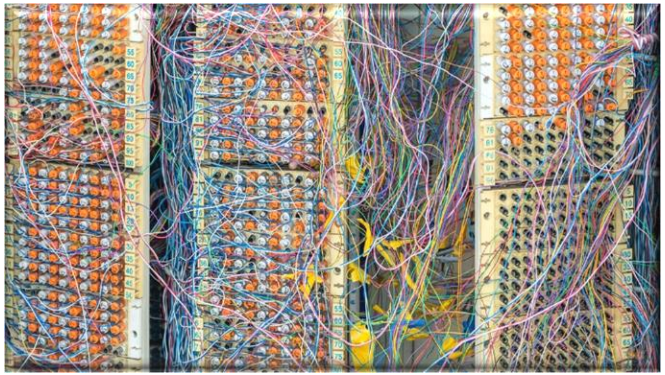
Use a common fork-join pool to search input strings to locate phrases that match

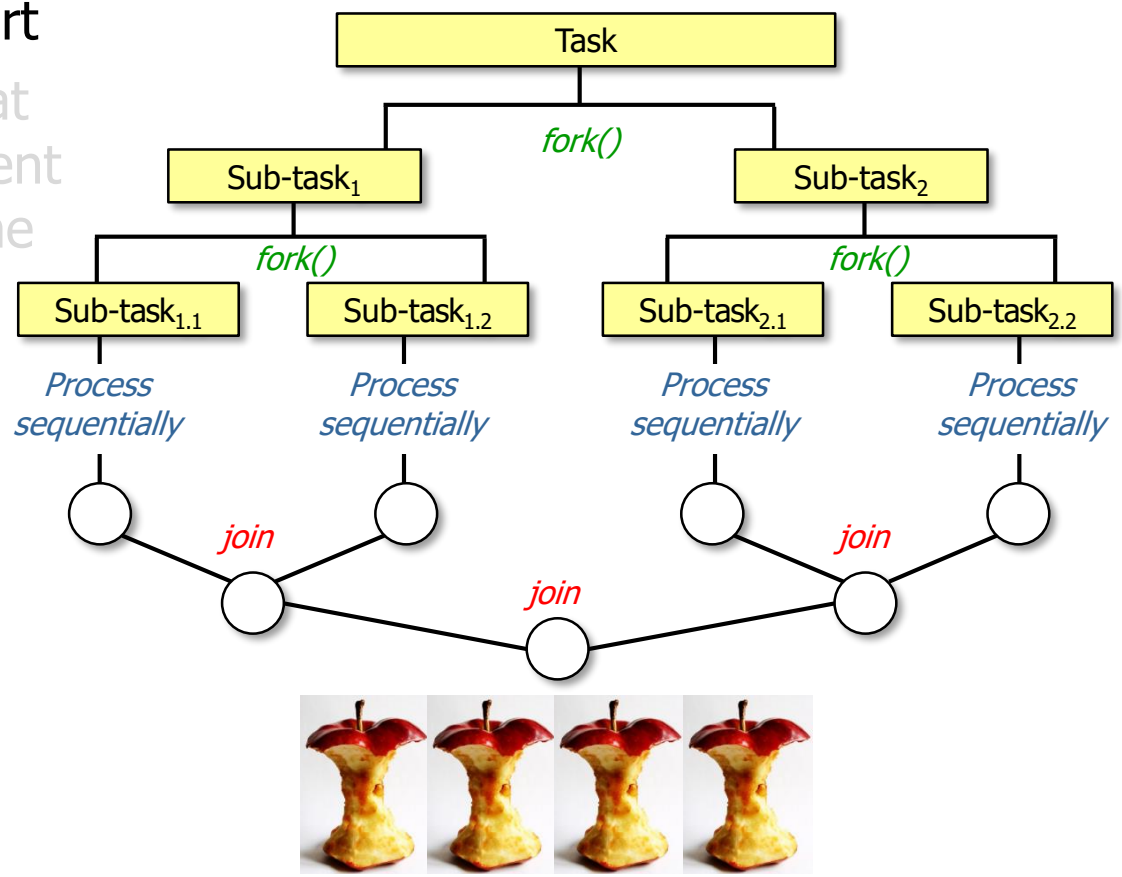


See github.com/douglascraigschmidt/LiveLessons/tree/master/SearchForkJoin

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





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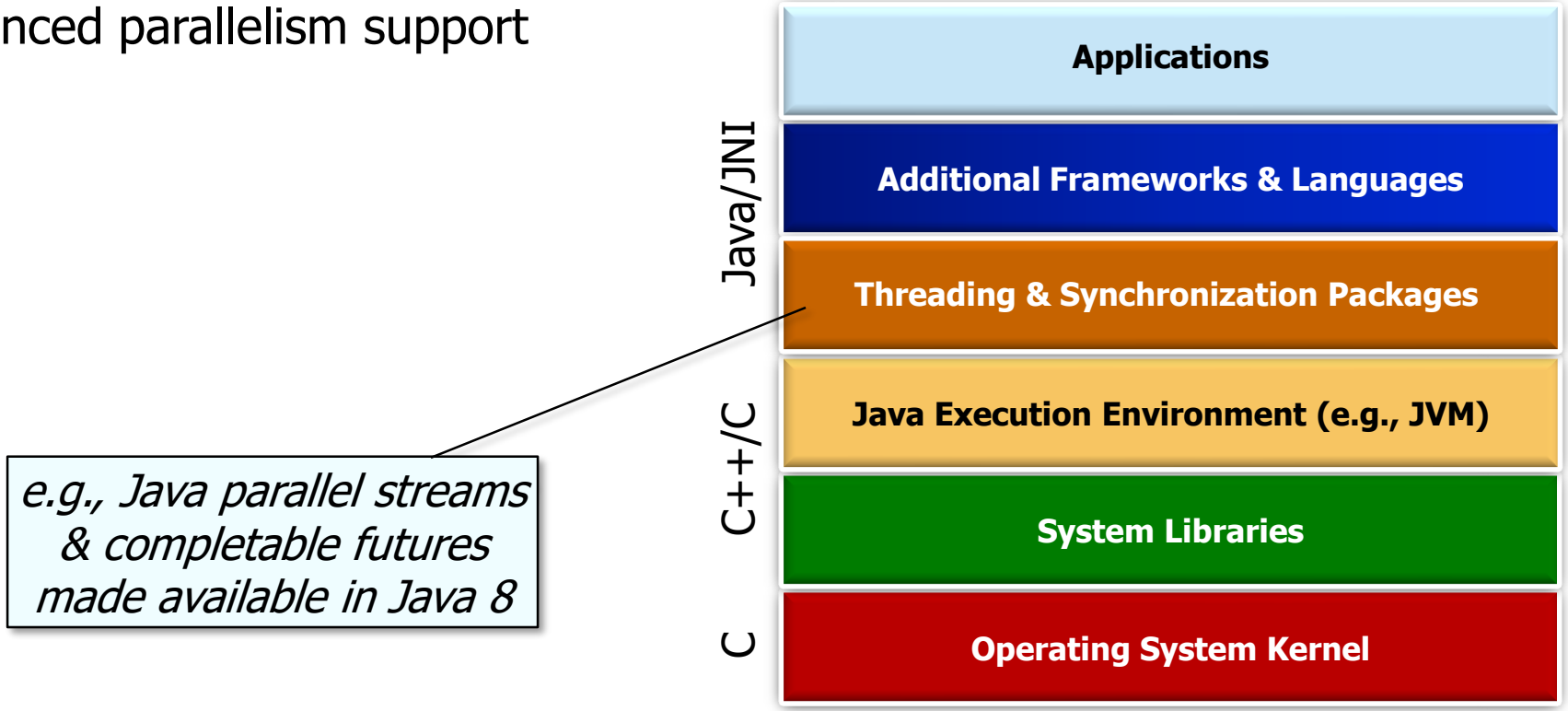
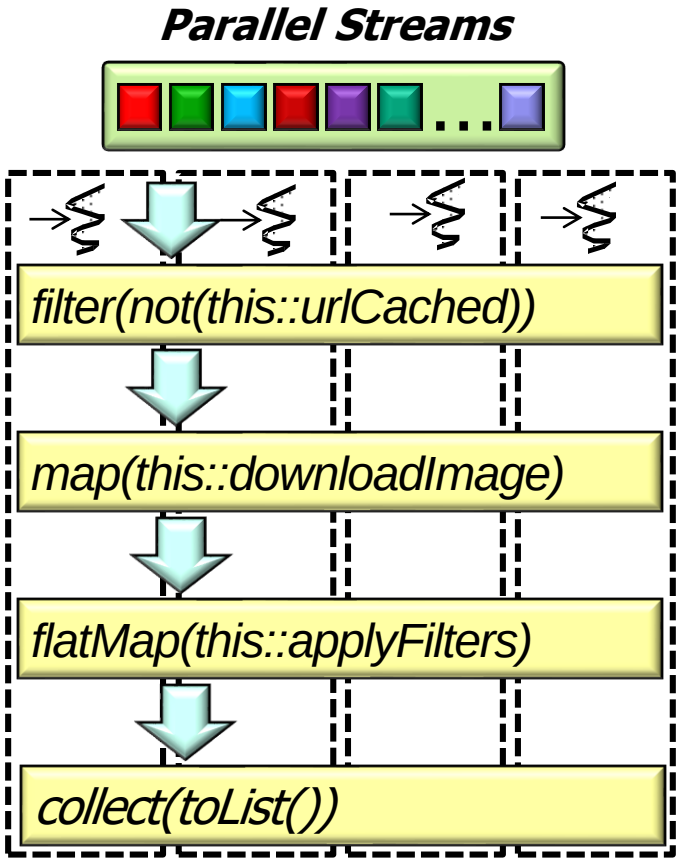


See en.wikipedia.org/wiki/Java_version_history#Java_SE_8

A Brief History of Parallelism in Java

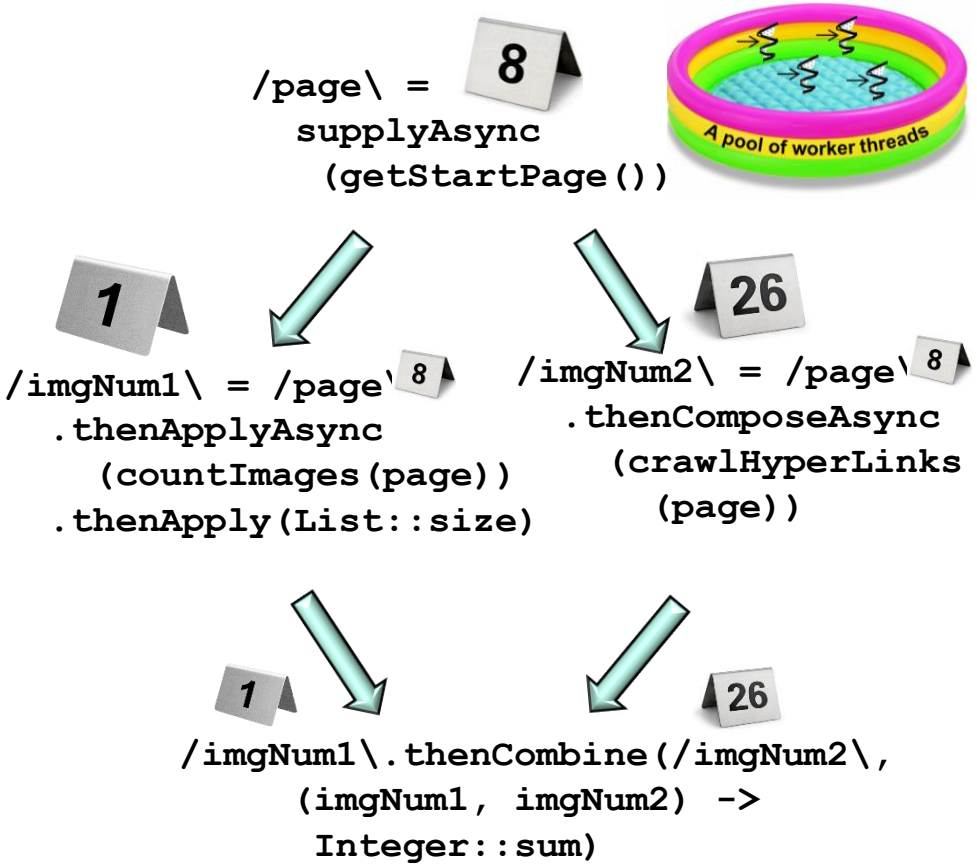
- Advanced parallelism support
  - Focus on functional programming for data parallelism



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

See github.com/douglascraigschmidt/LiveLessons/tree/master/ImageStreamGang

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```
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();
```

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

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

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

The Evolution of Java from Concurrency to Parallelism

The Evolution of Java from Concurrency to Parallelism

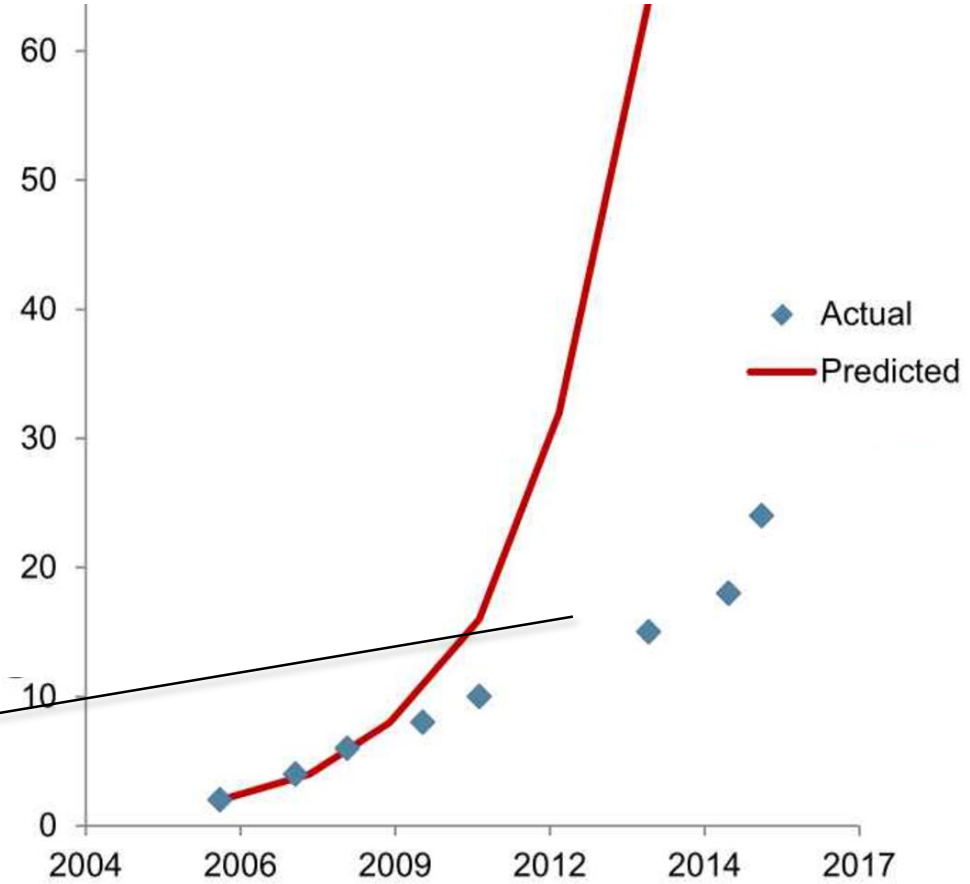
- Brian Goetz has an excellent talk about the evolution of Java from concurrent to parallel computing

See www.youtube.com/watch?v=NsDE7E8sIdQ

The Evolution of Java from Concurrency to Parallelism

- Brian Goetz has an excellent talk about the evolution of Java from concurrent to parallel computing

His talk emphasizes that Java 8 combines functional programming with fine-grained data parallelism to leverage many-core processors



See www.infoq.com/presentations/parallel-java-se-8

The Evolution of Java from Concurrency to Parallelism

- Rob Pike also has a good talk that explains the differences between concurrency & parallelism

His talk emphasizes that concurrency is about dealing with lots of things at once, whereas parallelism is about doing lots of things at once

See www.youtube.com/watch?v=cN_DpYBzKso

End of History of Concurrency & Parallelism in Java