The History of Concurrency Support in Java

Douglas C. Schmidt
d.schmidt@vanderbilt.edu
www.dre.vanderbilt.edu/~schmidt

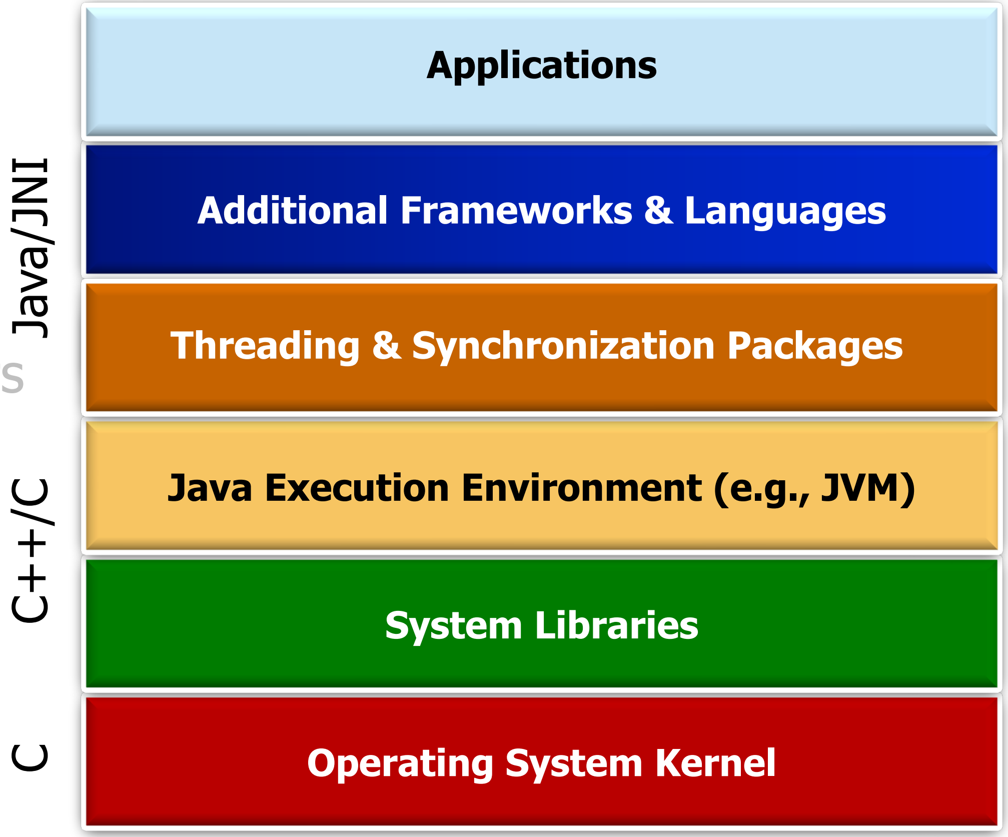
Professor of Computer Science

Institute for Software Integrated Systems

Vanderbilt University
Nashville, Tennessee, USA

Learning Objectives in this Part of the Lesson

- Understand the meaning of key concurrent programming concepts
- Recognize how Java supports concurrent programming concepts
- Be aware of common concurrency hazards faced by Java programmers
- Learn Java concurrency history


Java/JNI
C++/C
C
Applications
Additional Frameworks & Languages
Threading & Synchronization Packages
Java Execution Environment (e.g., JVM)
System Libraries
Operating System Kernel

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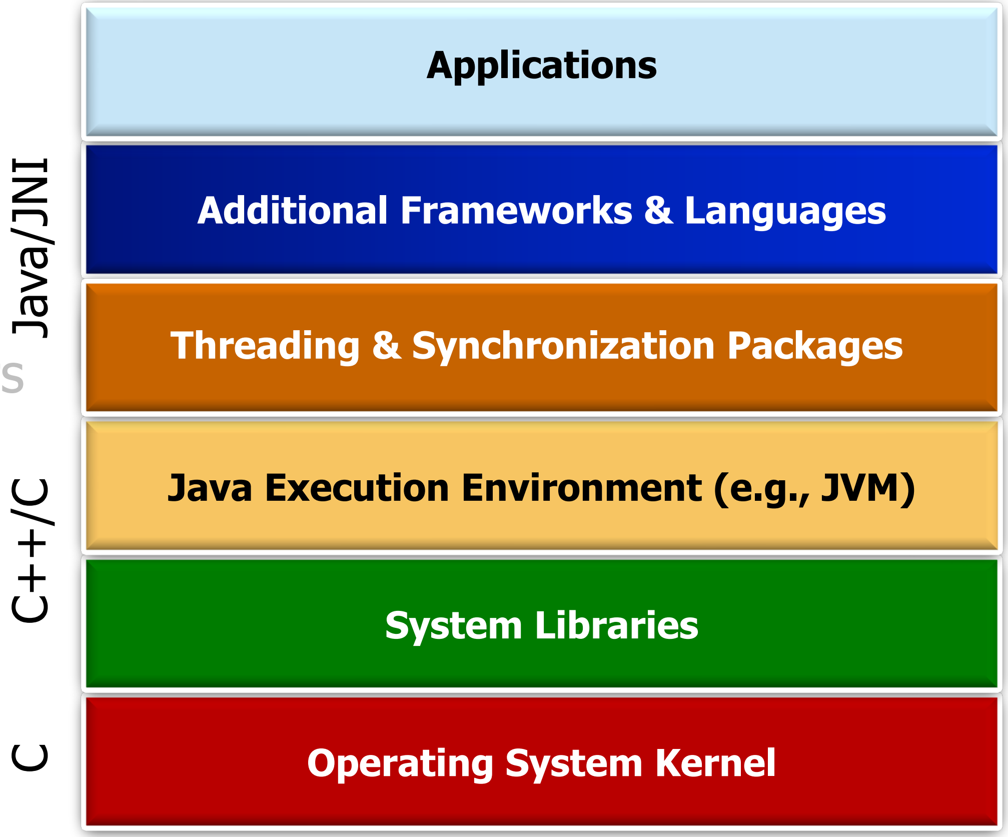

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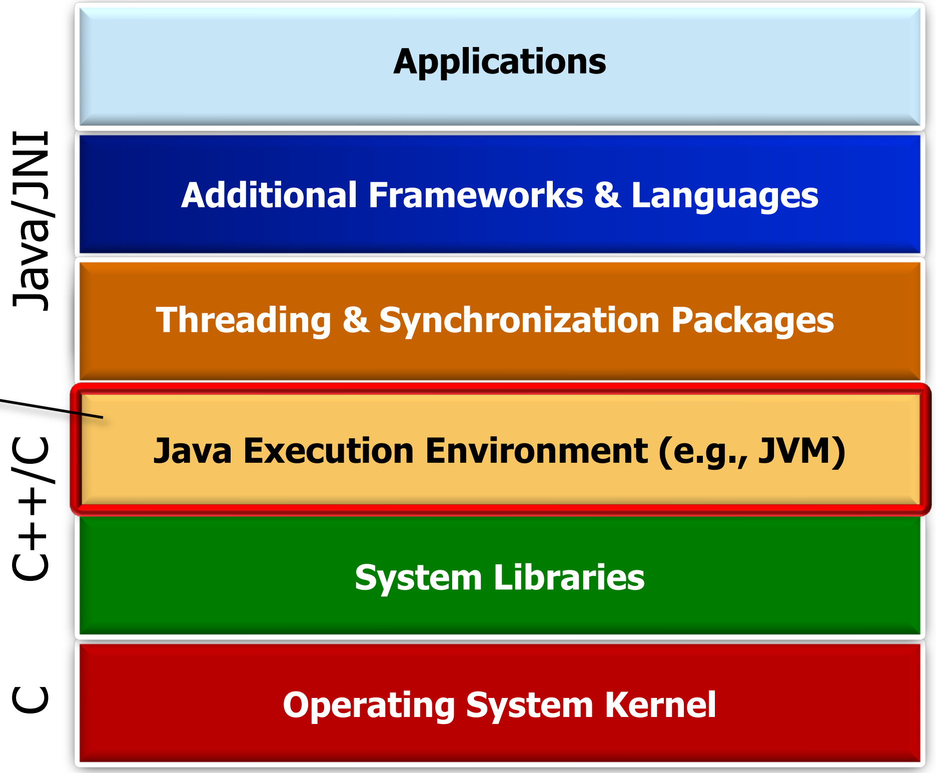
You may already know some of this history!

A Brief History of Concurrency in Java

A Brief History of Concurrency in Java

- Foundational concurrency support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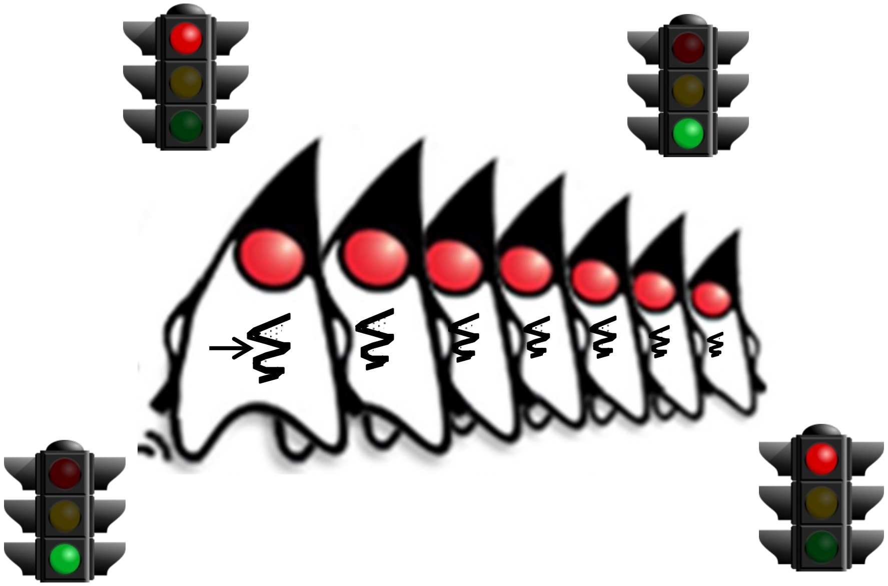
e.g., Java threads & built-in monitor objects were available in Java 1

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
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Allow multiple threads to communicate & interact 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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Create two Thread objects that produce & consume messages via the bounded buffer

See docs.oracle.com/javase/8/docs/api/java/lang/Thread.html

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

Start the producer & consumer threads

See docs.oracle.com/javase/8/docs/api/java/lang/Thread.html#start

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  thread.start();

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

Barrier that waits for the producer & consumer threads to finish running

See docs.oracle.com/javase/8/docs/api/java/lang/Thread.html#join

A Brief History of Concurrency in Java

- Foundational concurrency support
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```
class
SimpleBlockingBoundedQueue<E> {
  public E take() ...{
    synchronized(this) {
      while (mList.isEmpty())
        wait();

      notifyAll();

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

Demonstrates Java's built-in monitor object mutual exclusion & coordination primitives

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

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    wait();

   notifyAll();

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

Ensure mutually exclusive access to take()'s critical section via the intrinsic lock

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

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    }
  }
```

Coordinate interactions between multiple producer & consumer threads

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

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

      notifyAll();

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

The intrinsic lock is released after the next item on the list is removed/returned

See docs.oracle.com/javase/8/docs/api/java/util/LinkedList.html#poll

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

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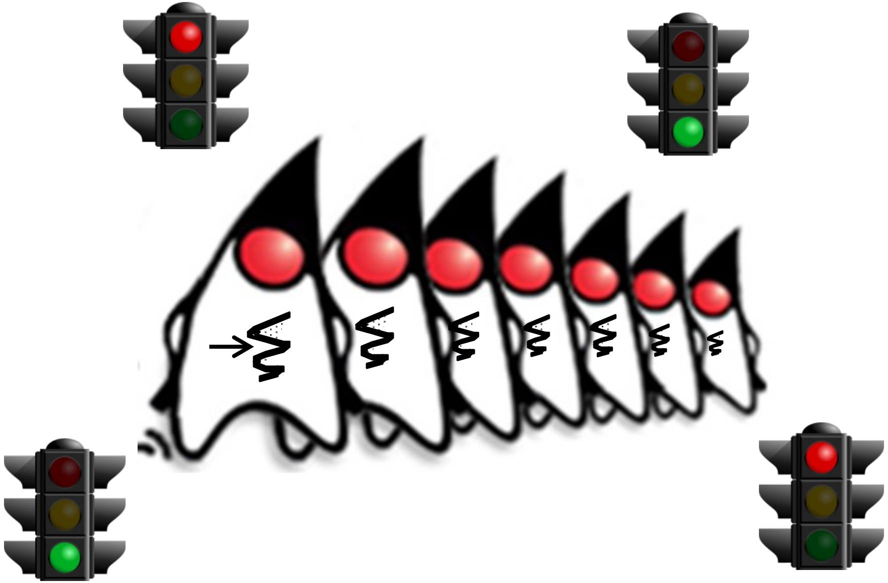
- Foundational concurrency support
  - Focus on basic multi-threading & synchronization primitives
  - Efficient, but low-level & very limited in capabilities
    - Many accidental complexities

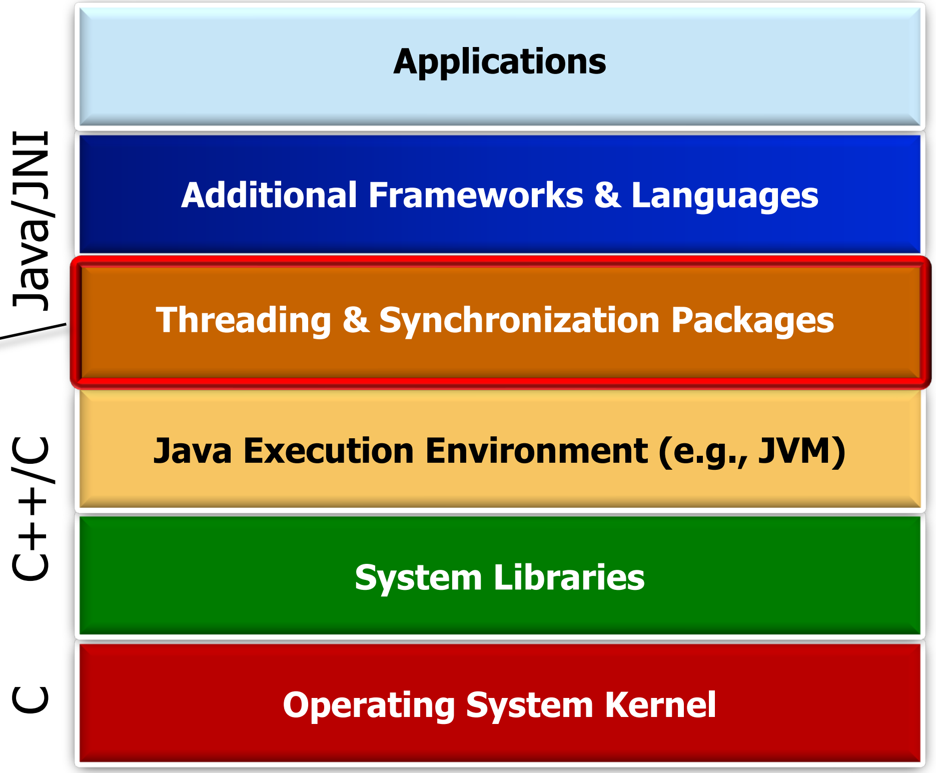


Accidental complexities arise from limitations with software techniques, tools, & methods

See en.wikipedia.org/wiki/No_Silver_Bullet

A Brief History of Concurrency in Java

- Advanced concurrency support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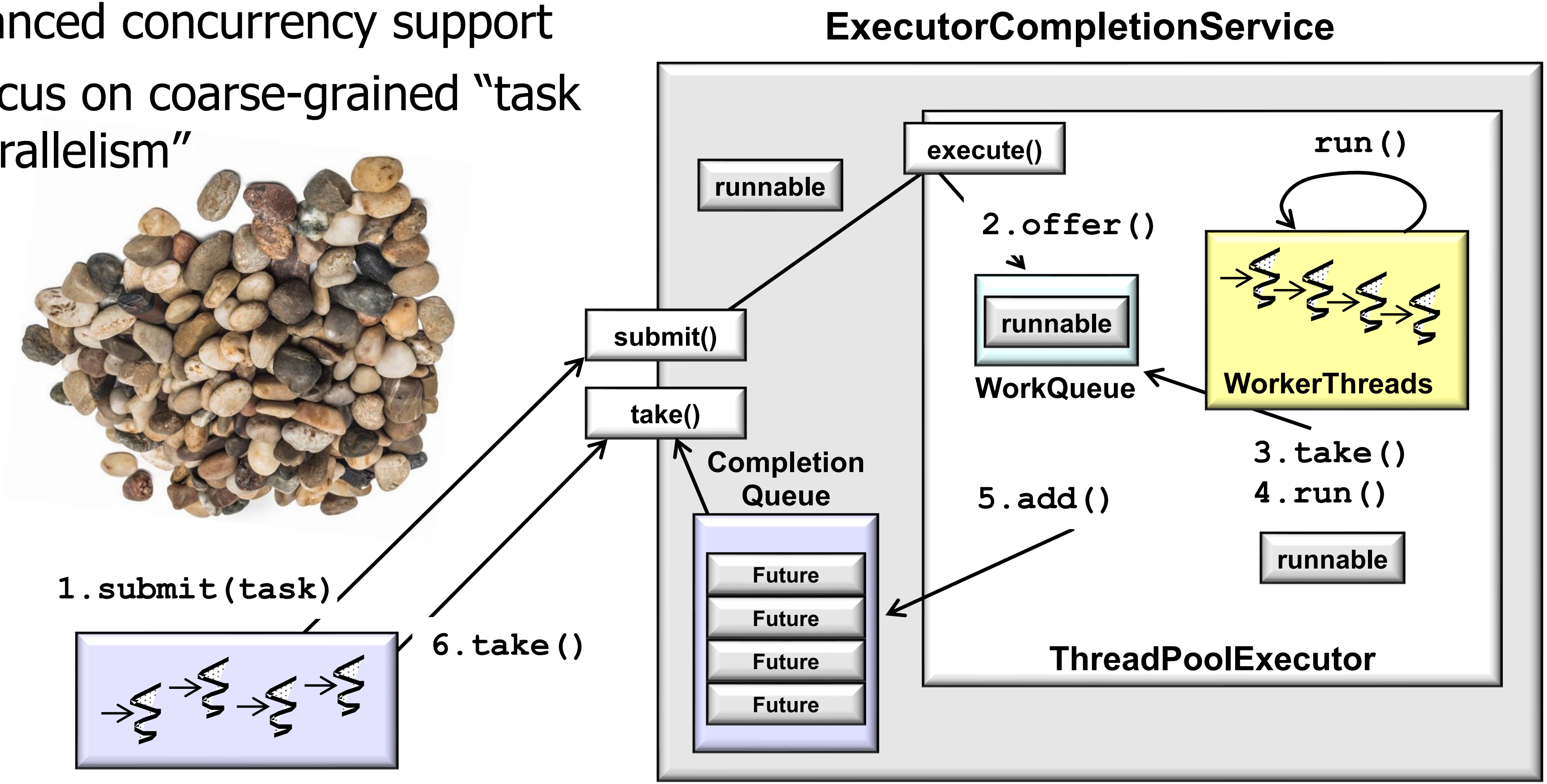
e.g., Java executor framework, advanced synchronizers, blocking queues, atomics, & concurrent collections all became available in Java 5+

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

A Brief History of Concurrency in Java

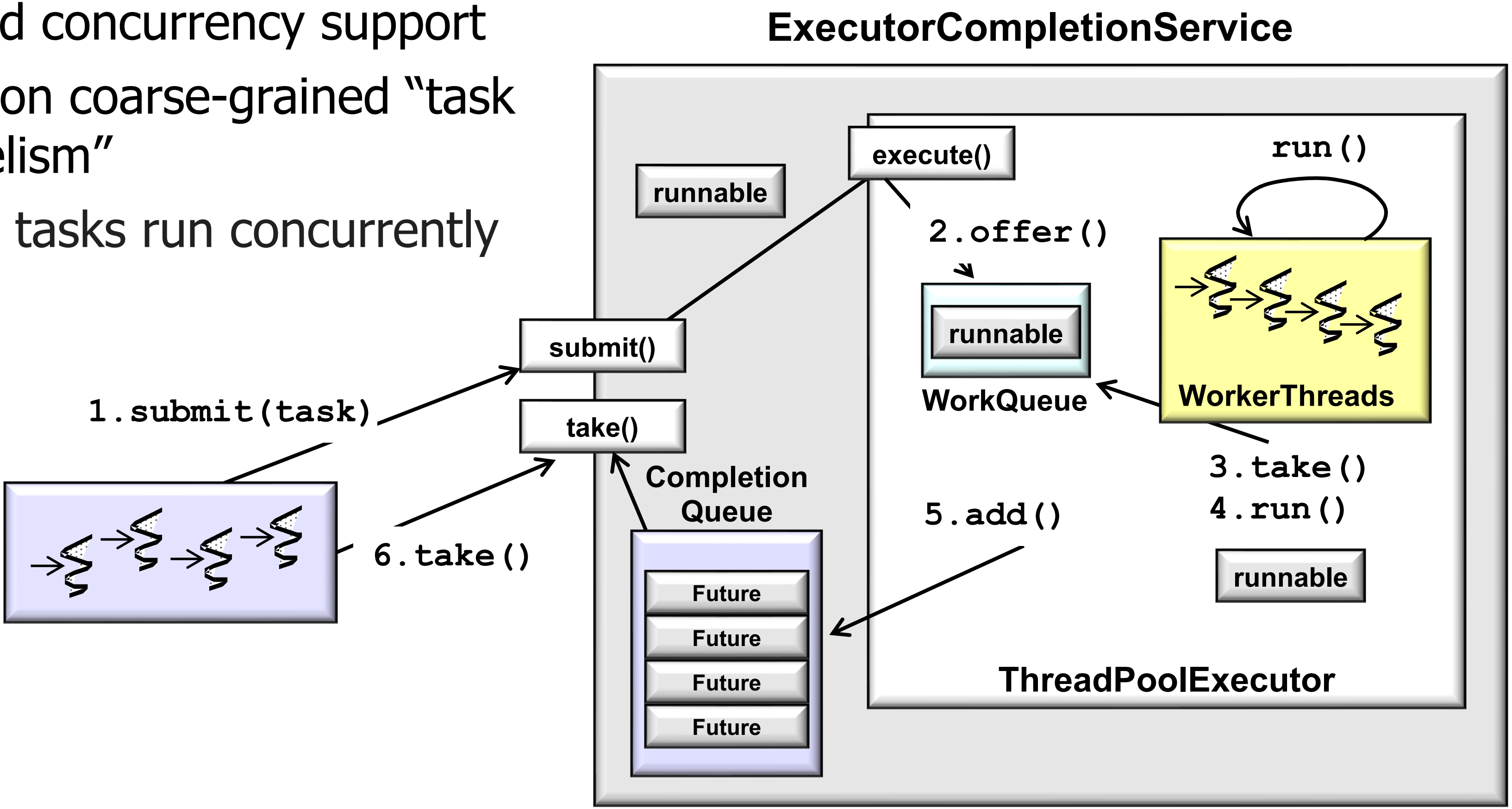
- Advanced concurrency support
  - Focus on coarse-grained “task parallelism”



See en.wikipedia.org/wiki/Task_parallelism

A Brief History of Concurrency in Java

- Advanced concurrency support
  - Focus on coarse-grained "task parallelism"
    - e.g., tasks run concurrently



The assumption then was there weren't many processor cores, e.g., 2 to 4

A Brief History of Concurrency in Java

- Advanced concurrency support
  - Focus on coarse-grained "task parallelism"
    - e.g., tasks 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,
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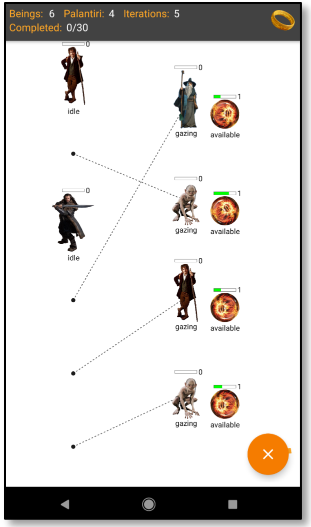
```



Beings: 6 Palantiri: 4 Iterations: 5
Completed: 0/30

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

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

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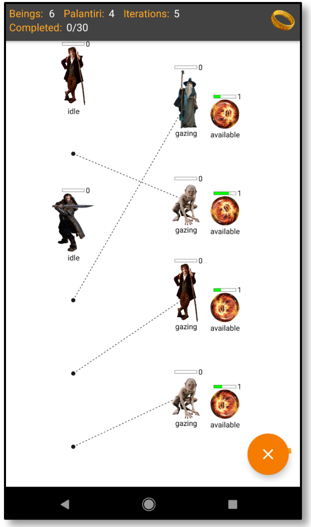

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Create a pool of threads that reuse a given/fixed # of threads operating off of a shared unbounded queue

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```

See docs.oracle.com/javase/8/docs/api/java/util/concurrent/Executors.html#newFixedThreadPool

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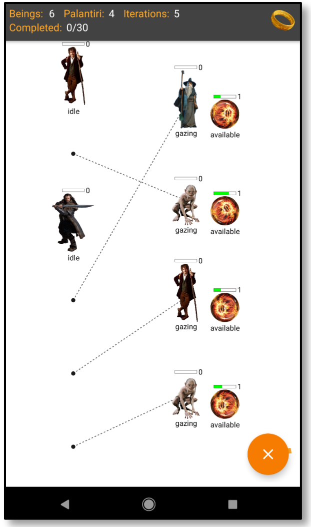
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This synchronizer allows a set of threads to all wait for each other to reach a common barrier point

See docs.oracle.com/javase/8/docs/api/java/util/concurrent/CyclicBarrier.html

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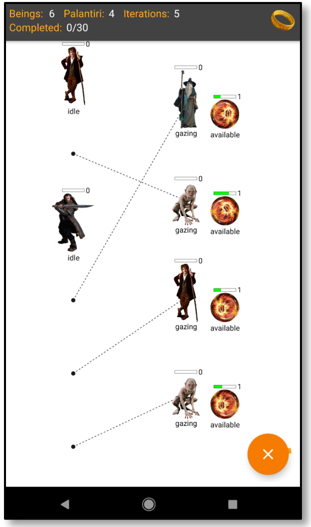

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This synchronizer allows one or more threads to wait for the completion of a set of operations being performed in other threads

See docs.oracle.com/javase/8/docs/api/java/util/concurrent/CountDownLatch.html

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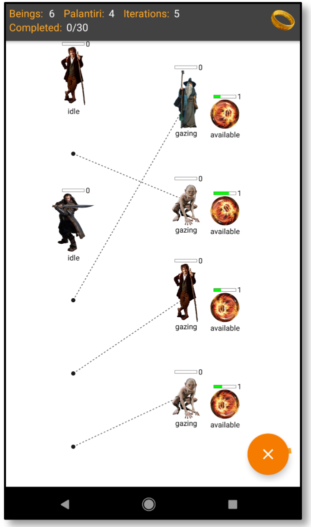

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Executes the given command at some time in the future in the fixed-size pool of threads

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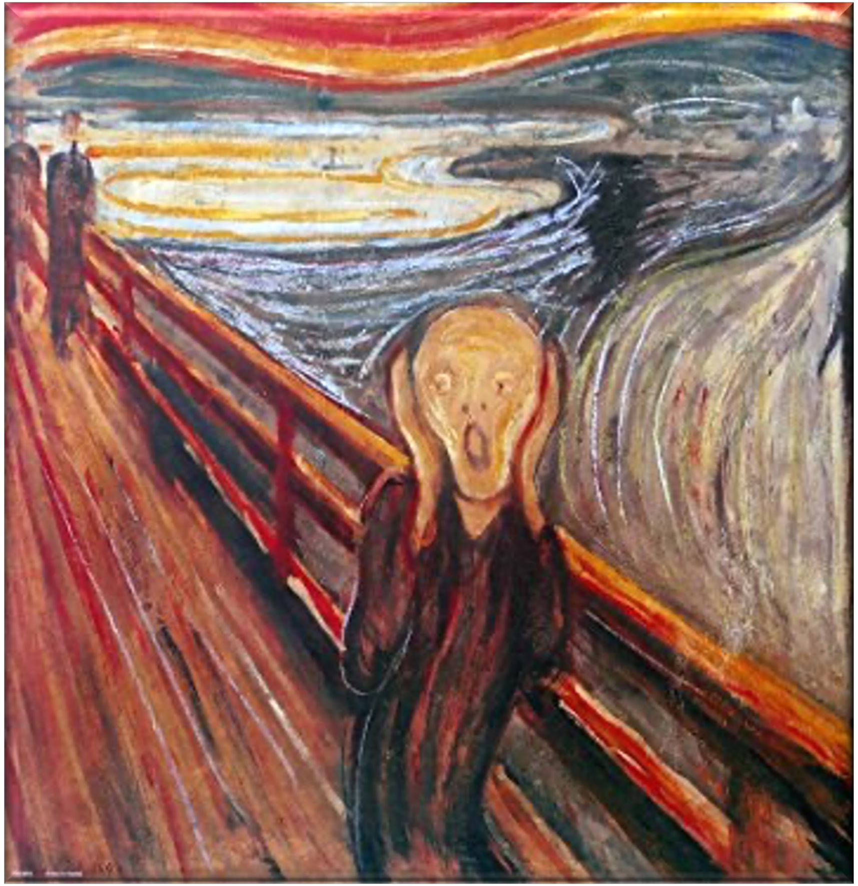
See docs.oracle.com/javase/8/docs/api/java/util/concurrent/Executor.html#execute

A Brief History of Concurrency in Java

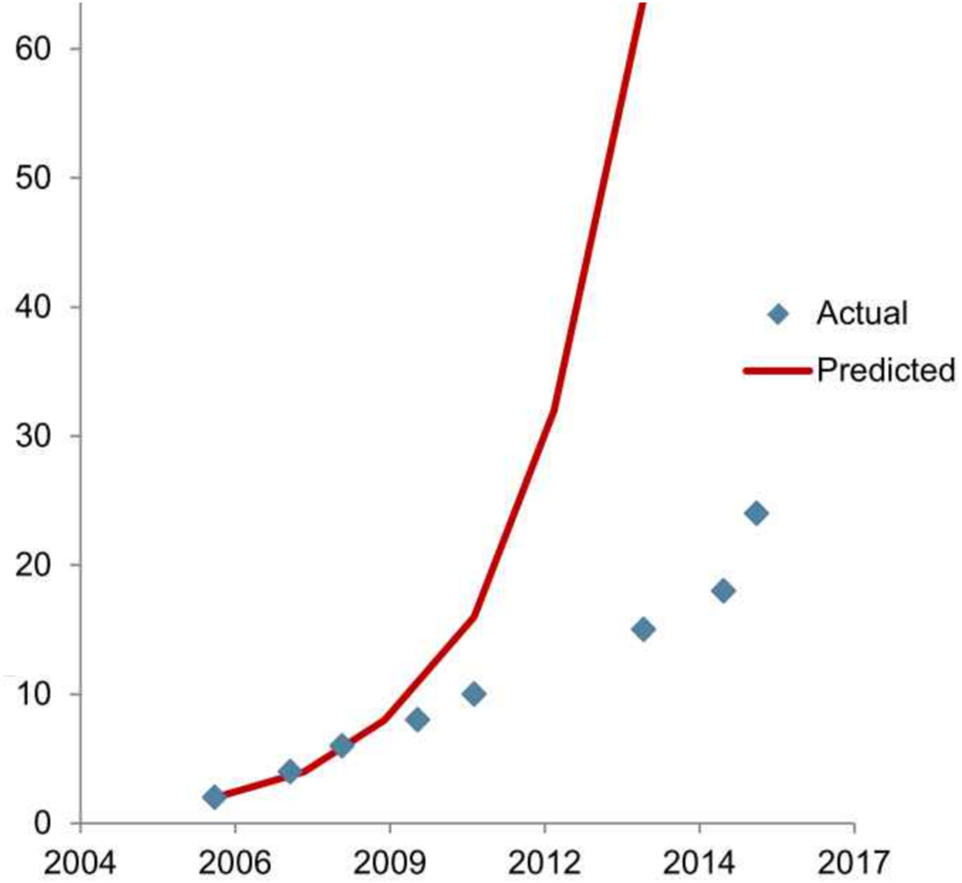
- Advanced concurrency support
  - Focus on coarse-grained "task parallelism"
  - Feature-rich & optimized, but also tedious & error-prone to program



See flylib.com/books/en/2.558.1/risks_of_threads.html

A Brief History of Concurrency in Java

- Advanced concurrency support
  - Focus on coarse-grained "task parallelism"
  - Feature-rich & optimized, but also tedious & error-prone to program
    - & scales poorly for modern multi-core processors



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

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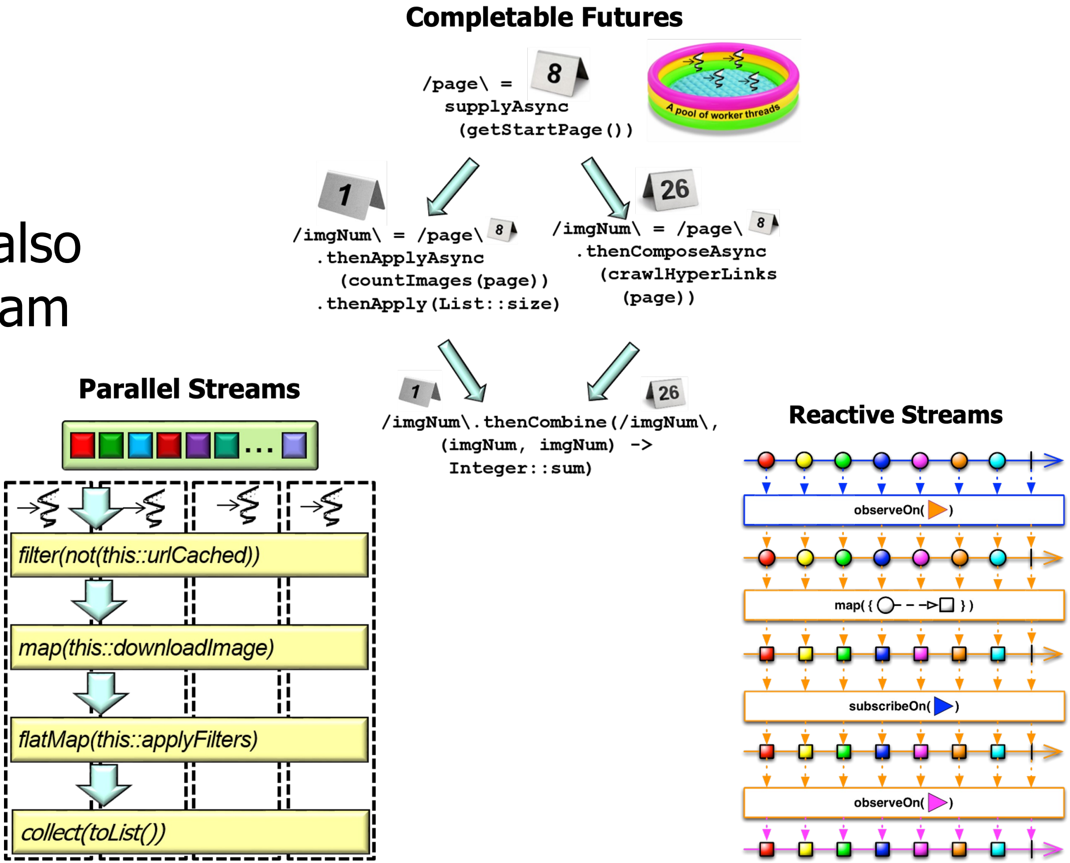
Motivates Java's parallel, async, & reactive programming frameworks



Completable Futures

```
/page\ =
  supplyAsync
    (getStartPage())
```

```
/imgNum\ = /page\
  .thenApplyAsync
    (countImages(page))
  .thenApply(List::size)
```

```
/imgNum\ = /page\
  .thenComposeAsync
    (crawlHyperLinks
      (page))
```

```
/imgNum\.thenCombine(/imgNum\,
  (imgNum, imgNum) ->
    Integer::sum)
```

Parallel Streams

filter(not(this::urlCached))

map(this::downloadImage)

flatMap(this::applyFilters)

collect(toList())

Reactive Streams

See upcoming lesson on "*How Parallel Programs Are Developed in Java*"

End of the History of Concurrency Support in Java

Discussion Questions

1. Which of the following were concurrency features added in Java 5?

   a. *Shared objects*

   b. *Advanced synchronizers*

   c. *Message passing*

   d. *Blocking queues*

   e. *Executor framework*

   f. *Mutual exclusion*

   g. *Concurrent collections*