The History of Concurrency Support in Java

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

You may 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 were available in Java 1

See [en.wikipedia.org/wiki/Java_version_history#JDK_1.0](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

```java
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/douglasraigschmidt/LiveLessons/tree/master/SimpleBlockingQueue](https://github.com/douglasraigschmidt/LiveLessons/tree/master/SimpleBlockingQueue)
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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();

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.start();
}

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

See [docs.oracle.com/javase/8/docs/api/java/lang/Thread.html#start](docs.oracle.com/javase/8/docs/api/java/lang/Thread.html#start)
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};

for (Thread thread : threads) {
    thread.start();
}

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

Wait for the producer & consumer threads to finish running

See [docs.oracle.com/javase/8/docs/api/java/lang/Thread.html#join](http://docs.oracle.com/javase/8/docs/api/java/lang/Thread.html#join)
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Demonstrates Java's built-in monitor object mutual exclusion & coordination primitives

class SimpleBlockingBoundedQueue<E> {
    public E take() {...
        synchronized(this) {
            while (mList.isEmpty())
                wait();

            notifyAll();

            return mList.poll();
        }
    }
}
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```java
class SimpleBlockingBoundedQueue<E> {
    public E take() {...
        synchronized (this) {
            while (mList.isEmpty())
                wait();
            notifyAll();
            return mList.poll();
        }
    }
}
```

Ensure mutually exclusive access to `take()`'s critical section

See [docs.oracle.com/javase/tutorial/essential/concurrency/locksync.html](https://docs.oracle.com/javase/tutorial/essential/concurrency/locksync.html)
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```java
class SimpleBlockingBoundedQueue<E> {
    public E take() {...
        synchronized(this) {
            while (mList.isEmpty())
                wait();
            notifyAll();
            return mList.poll();
        }
    }
}
```

**Coordinate interactions between multiple producer & consumer threads**

See [docs.oracle.com/javase/tutorial/essential/concurrency/guardmeth.html](docs.oracle.com/javase/tutorial/essential/concurrency/guardmeth.html)
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

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

See [en.wikipedia.org/wiki/No_Silver_Bullet](en.wikipedia.org/wiki/No_Silver_Bullet)

Accidental complexities arise from limitations with software techniques, tools, & methods
A Brief History of Concurrency in Java

- Advanced concurrency support

See [en.wikipedia.org/wiki/Java_version_history#J2SE_5.0](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”

See en.wikipedia.org/wiki/Task_parallelism
A Brief History of Concurrency in Java

- Advanced concurrency support
- Focus on course-grained “task parallelism”
  - e.g., multiple tasks can be running 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 course-grained “task parallelism”
  - e.g., multiple tasks can be running concurrently

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

```java
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));
```

See [github.com/douglascraigschmidt/LiveLessons/tree/master/PalantiriManagerApplication](https://github.com/douglascraigschmidt/LiveLessons/tree/master/PalantiriManagerApplication)
A Brief History of Concurrency in Java

- Advanced concurrency support
- Focus on course-grained “task parallelism”
  - e.g., multiple tasks can be running concurrently

`ExecutorService executor = Executors.newFixedThreadPool(numOfBeings, mThreadFactory);`

```java
... 
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”
- e.g., multiple tasks can be running concurrently

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

```java
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));
```

See [docs.oracle.com/javase/8/docs/api/java/util/concurrent/CyclicBarrier.html](docs.oracle.com/javase/8/docs/api/java/util/concurrent/CyclicBarrier.html)
A Brief History of Concurrency in Java

- Advanced concurrency support
- Focus on course-grained “task parallelism”
- e.g., multiple tasks can be running concurrently

A synchronizer that allows one or more threads to wait until a set of operations being performed in other threads completes

```java
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));
```

See [docs.oracle.com/javase/8/docs/api/java/util/concurrent/CountDownLatch.html](http://docs.oracle.com/javase/8/docs/api/java/util/concurrent/CountDownLatch.html)
A Brief History of Concurrency in Java

- Advanced concurrency support
- Focus on course-grained “task parallelism”
- e.g., multiple tasks can be running concurrently

Example code:

```java
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));
```

See [docs.oracle.com/javase/8/docs/api/java/util/concurrent/Executor.html#execute](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 course-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 course-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](http://www.infoq.com/presentations/parallel-java-se-8)
A Brief History of Concurrency in Java

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

Motivates the need for Java’s parallel programming frameworks

See upcoming lesson on “How Parallel Programs Are Developed in Java”
End of the History of Concurrency Support in Java