Example Application of Java CyclicBarrier

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Learning Objectives in this Part of the Lesson

- Understand the structure & functionality of Java CyclicBarrier
- Recognize the key methods in the Java CyclicBarrier
- Know how to program with Java CyclicBarrier in practice

```java
class GCDGCyclicBarrierWorker implements Runnable {
    private final CyclicBarrier mEntryBarrier;
    private final CyclicBarrier mExitBarrier; ...

    GCDGCyclicBarrierWorker(CyclicBarrier entryBarrier,
                          CyclicBarrier exitBarrier, ...) {
        mEntryBarrier = entryBarrier; mExitBarrier = exitBarrier;
        ...
    }

    public void run() {
        ...
        mEntryBarrier.await();
        runTest();
        mExitBarrier.await();
        ...
    }
}
```
Overview of the GCD App
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- This Android app uses CyclicBarrier objects to coordinate the concurrent benchmarking of four Greatest Common Divisor (GCD) algorithms.
- GCD computes the largest positive integer that is a divisor of two numbers.
- e.g., the GCD of 80 & 120 = 40

See [en.wikipedia.org/wiki/Greatest_common_divisor](http://en.wikipedia.org/wiki/Greatest_common_divisor)
Overview of the GCD App

- This Android app uses CyclicBarrier objects to coordinate the concurrent benchmarking of four Greatest Common Divisor (GCD) algorithms
  - GCD computes the largest positive integer that is a divisor of two numbers
  - Four GCD algorithms are tested
Overview of the GCD App

- This Android app uses CyclicBarrier objects to coordinate the concurrent benchmarking of four Greatest Common Divisor (GCD) algorithms
  - GCD computes the largest positive integer that is a divisor of two numbers
  - Four GCD algorithms are tested
    - The gcd() method defined by BigInteger

See docs.oracle.com/javase/8/docs/api/java/math/BigInteger.html#gcd
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    - The gcd() method defined by BigInteger
    - An iterative Euclid algorithm

See [en.wikipedia.org/wiki/Euclidean_algorithm](en.wikipedia.org/wiki/Euclidean_algorithm)
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    - A recursive Euclid algorithm
    - A complex GCD algorithm that uses binary arithmetic

See en.wikipedia.org/wiki/Binary_GCD_algorithm
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However, the details of these algorithms are not important for our discussion.
GCDCyclicBarrierTest Class Walkthrough
Create worker threads that use exit & entry barrier CyclicBarrier objects

class GCDCyclicBarrierTest {
  @Test public void testGCDCyclicBarrierTester() {
    List<GCDTuple> gcdTests = makeGCDTuples();

    CyclicBarrier entryBarrier =
        new CyclicBarrier(gcdTests.size() + 1, () ->
            GCDCyclicBarrierWorker.initializeInput(sITERATIONS));
    CyclicBarrier exitBarrier =
        new CyclicBarrier(gcdTests.size() + 1);

    for (int cycle = 1; cycle <= sCYCLES; cycle++) {
      gcdTests.forEach(gcdTuple -> new Thread(new
        GCDCyclicBarrierWorker(entryBarrier, exitBarrier,
            gcdTuple, this)).start());
      System.out.println("Starting tests");
      entryBarrier.await();
      System.out.println("Waiting for results");
      exitBarrier.await();
      System.out.println("All tests done"); ...

See GCD/CyclicBarrier/app/src/test/java/edu/vandy/gcdtesttask/GCDCyclicBarrierTest.java
• Create worker threads that use exit & entry barrier CyclicBarrier objects

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Entry point into the unit test
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GCDCyclicBarrierTest Class Walkthrough

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            System.out.println("Starting tests");
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```

Barrier action allocates each cycle’s input
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        CyclicBarrier exitBarrier =
                new CyclicBarrier(gcdTests.size() + 1);
        
        for (int cycle = 1; cycle <= sCYCLES; cycle++) {
            gcdTests.forEach(gcdTuple -> new Thread(new
                    GCDCyclicBarrierWorker(entryBarrier, exitBarrier,
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            System.out.println("Starting tests");
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GCDCyclicBarrierTest Class Walkthrough

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        for (int cycle = 1; cycle <= sCYCLES; cycle++) {
            gcdTests.forEach(gcdTuple ->
                new Thread(new GCDCyclicBarrierWorker(entryBarrier, exitBarrier,
                    gcdTuple, this)).start());

            System.out.println("Starting tests");
            entryBarrier.await();
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```

Iterate through each cycle
Create worker threads that use exit & entry barrier CyclicBarrier objects

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                        gcdTuple, this)).start());

                System.out.println("Starting tests");
                entryBarrier.await();
                System.out.println("Waiting for results");
                exitBarrier.await();
                System.out.println("All tests done"); ...
```

Create & start threads w/barriers
class GCDCyclicBarrierTest {
    @Test
    public void testGCDCyclicBarrierTester() {
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        for (int cycle = 1; cycle <= sCYCLES; cycle++) {
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                    gcdTuple, this)).start());
            System.out.println("Starting tests");
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            System.out.println("Waiting for results");
            exitBarrier.await();
            System.out.println("All tests done"); ...
        }
    }
}
class GCDCyclicBarrierTest {
    @Test public void testGCDCyclicBarrierTester() {
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                gcdTuple, this)).start());

            System.out.println("Starting tests");
            entryBarrier.await();
            System.out.println("Waiting for results");
            exitBarrier.await();
            System.out.println("All tests done"); ...
        }
    }
}

• Create worker threads that use exit & entry barrier CyclicBarrier objects

Let all worker threads proceed at the same time, fixing limitation with CountDownLatch

See previous lesson on “Java CountDownLatch”
GCDCyclicBarrierTest Class Walkthrough

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    @Test public void testGCDCyclicBarrierTester() {
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            gcdTests.forEach(gcdTuple -> new Thread(new GCDCyclicBarrierWorker()
                entryBarrier, exitBarrier, gcdTuple, this)).start());

            System.out.println("Starting tests");
            entryBarrier.await();
            System.out.println("Waiting for results");
            exitBarrier.await();
            System.out.println("All tests done");
        }
    }
}
```

After `await()` returns for a CyclicBarrier it will be reset (& is thus reusable) *without* needing to create a new CyclicBarrier instance.
GCDCyclicBarrierWorker Class Walkthrough
This class applies two entry & exit barrier CyclicBarrier objects to coordinate the benchmarking of a given GCD algorithm implementation.

```java
class GCDCyclicBarrierWorker implements Runnable {
    private final CyclicBarrier mEntryBarrier;
    private final CyclicBarrier mExitBarrier;
    ...

    GCDCyclicBarrierWorker(CyclicBarrier entryBarrier,
                           CyclicBarrier exitBarrier, ...) {
        mEntryBarrier = entryBarrier; mExitBarrier = exitBarriere;
        ...
    }

    public void run() {
        ...
        mEntryBarrier.await();
        runTest();
        mExitBarrier.await();
        ...
    }
}
```

See [GCD/CyclicBarrier/app/src/main/java/edu/vandy/gcdtesttask/presenter/GCDCyclicBarrierWorker.java](GCD/CyclicBarrier/app/src/main/java/edu/vandy/gcdtesttask/presenter/GCDCyclicBarrierWorker.java)
• This class applies two entry & exit barrier CyclicBarrier objects to coordinate the benchmarking of a given GCD algorithm implementation

class GCDCyclicBarrierWorker implements Runnable {
    private final CyclicBarrier mEntryBarrier;
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    GCDCyclicBarrierWorker(CyclicBarrier entryBarrier,
                            CyclicBarrier exitBarrier, ...) {
        mEntryBarrier = entryBarrier; mExitBarrier = exitBarrier;
        ...
    }

    public void run() {
        ...
     mEntryBarrier.await();
     runTest();
     mExitBarrier.await();
     ...
    }
GCDCyclicBarrierWorker Class Walkthrough

• This class applies two entry & exit barrier CyclicBarrier objects to coordinate the benchmarking of a given GCD algorithm implementation

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        ...
    }

    public void run() {
        ...
        mEntryBarrier.await();
        runTest();
        mExitBarrier.await();
        ...
    }

    This hook method executes after the thread is started
GCDCyclicBarrierWorker Class Walkthrough

- This class applies two entry & exit barrier CyclicBarrier objects to coordinate the benchmarking of a given GCD algorithm implementation

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        mEntryBarrier = entryBarrier; mExit Barrier = exitBarrier;
        ...
    }

    public void run() {
        ...
        mEntryBarrier.await();
        runTest();
        mExitBarrier.await();
        ...
    }
}
```

This entry barrier causes all worker threads to wait until they are all ready, thus fixing the earlier limitation with CountDownLatch.

See previous lesson on "Java CountDownLatch"
GCDCyclicBarrierWorker Class Walkthrough

- This class applies two entry & exit barrier CyclicBarrier objects to coordinate the benchmarking of a given GCD algorithm implementation

    class GCDCyclicBarrierWorker implements Runnable {
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                                CyclicBarrier exitBarrier, ...) {
            mEntryBarrier = entryBarrier; mExitBarrier = exitBarrier;
            ...
        }

        public void run() {
            ...
            mEntryBarrier.await();
            runTest();  // Run the GCD algorithm associated with this object
            mExitBarrier.await();
            ...
        }
    }
GCDCyclicBarrierWorker Class Walkthrough

• This class applies two entry & exit barrier CyclicBarrier objects to coordinate the benchmarking of a given GCD algorithm implementation

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                           CyclicBarrier exitBarrier, ...) {
        mEntryBarrier = entryBarrier; mExitBarrier = exitBarrier;
        ...
    }

    public void run() {
        ...
        mEntryBarrier.await();
        runTest();
        mExitBarrier.await();
        ...
    }

    Exit barrier waits until all threads are done before returning
End of Example Application
Java CyclicBarrier