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 GCDCyclicBarrierWorker implements Runnable {

    private final CyclicBarrier mEntryBarrier;
    private final CyclicBarrier mExitBarrier;

    GCDCyclicBarrierWorker(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
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
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
    • An iterative Euclid algorithm

See en.wikipedia.org/wiki/Euclidean_algorithm
Overview of the GCD App

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    - An iterative Euclid algorithm
    - A recursive Euclid algorithm

Overview of the GCD App

• This Android app uses CyclicBarrier objects to coordinate the concurrent benchmarking of four Greatest Common Divisor (GCD) algorithms
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    • The gcd() method defined by BigInteger
    • An iterative Euclid algorithm
    • A recursive Euclid algorithm
    • A complex GCD algorithm that uses binary arithmetic

See en.wikipedia.org/wiki/Binary_GCD_algorithm
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
    • An iterative Euclid algorithm
    • A recursive Euclid algorithm
    • A complex GCD algorithm that uses binary arithmetic

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

```java
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](GCD/CyclicBarrier/app/src/test/java/edu/vandy/gcdtesttask/GCDCyclicBarrierTest.java)
class GCDCyclicBarrierTest {
    @Test public void testGCDCyclicBarrierTester() {
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        CyclicBarrier entryBarrier =
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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();
            System.out.println("Waiting for results");
            exitBarrier.await();
            System.out.println("All tests done"); ...
        }
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}
GCDCyclicBarrierTest Class Walkthrough

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

```java
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");
        }
    }
}
```

*Initialize all the GCD algorithms*
class GCDCyclicBarrierTest {
    @Test public void testGCDCyclicBarrierTester() {
        List<GCDTuple> gcdTests = makeGCDTuples();

        CyclicBarrier entryBarrier = Create entry barrier
            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"); ...
        }
    }
}

We add a "+ 1" for the thread that initializes the tests
Create worker threads that use exit & entry barrier CyclicBarrier objects

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        CyclicBarrier entryBarrier =
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                GCDCyclicBarrierWorker.initializeInput(sITERATIONS));

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

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

Barrier action (re)allocates each cycle’s input
• Create worker threads that use exit & entry barrier CyclicBarrier objects

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            System.out.println("Starting tests");
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Create worker threads that use exit & entry barrier CyclicBarrier objects

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                new Thread(new GCDCyclicBarrierWorker(entryBarrier, exitBarrier,
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            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

See upcoming walkthrough of GCDCyclicBarrierWorker
• Create worker threads that use exit & entry barrier CyclicBarrier objects

```java
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        List<GCDTuple> gcdTests = makeGCDTuples();

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                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"); ...
        }
    }
}
```

Don't start just yet
GCDCyclicBarrierTest Class Walkthrough

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

```java
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(); // Let all worker threads proceed at the
         System.out.println("Waiting for results"); // same time, fixing
         exitBarrier.await(); // limitation with CountDownLatch
         System.out.println("All tests done"); ...
```
GCDCyclicBarrierTest Class Walkthrough

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

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

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

After await() returns for a CyclicBarrier it will be reset (& is thus reusable) without needing to create a new CyclicBarrier instance
GCDCyclicBarrierWorker Class Walkthrough
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 = exitBarrier;
        ...
    }

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

See GCD/CyclicBarrier/app/src/main/java/edu/vandy/gcdtesttask/presenter/GCDCyclicBarrierWorker.java
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 = exitBarrier;
        ...
    }

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

*Initialize barrier fields*
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 {
    private final CyclicBarrier mEntryBarrier;
    private final CyclicBarrier mExitBarrier;
    ...

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

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

    This hook method executes after the thread is started
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 = 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.
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 = exitBarrier;
        ...
    }

    public void run() {
        ...
        mEntryBarrier.await();
        runTest(); \textcolor{red}{\textbf{Run the GCD algorithm associated with this object}}
        mExitBarrier.await();
        ...
    }
}
```

Important
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 = 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