Example Application of Java Phaser

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Learning Objectives in this Part of the Lesson

• Understand the structure & functionality of the Java Phaser barrier synchronizer

• Recognize the key methods in the Java Phaser

• Know how to program with Java Phaser in practice

```java
void runOneShotTasks(List<MyTask> tasks) {
    Phaser entryPhaser = new Phaser(1);
    Phaser exitPhaser = new Phaser(tasks.size());

    tasks.forEach(task -> {
        entryPhaser.register();
        new Thread(() -> {
            entryPhaser.arriveAndAwaitAdvance();
            task.run();
            exitPhaser.arrive();
        }).start();
    });
    entryPhaser.arriveAndDeregister();
    exitPhaser.awaitAdvance(0);
}
```

This program expands on the pithy examples in the Java documentation at [docs.oracle.com/javase/8/docs/api/java/util/concurrent/Phaser.html](docs.oracle.com/javase/8/docs/api/java/util/concurrent/Phaser.html)
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            entryPhaser.arriveAndAwaitAdvance();
            task.run();
            exitPhaser.arrive();
        }).start();
    });
    entryPhaser.arriveAndDeregister();
    exitPhaser.awaitAdvance(0);
}
```

Showcases Phasers used as entry & exit barriers, in addition to one-shot & cyclic barriers.
Test Driver Program
Walkthrough
Test Driver Program Walkthrough

- Main entry point into the test program

```java
private static List<MyTask> makeTasks() {
    return IntStream
        .rangeClosed(1, sNUMBER_OF_TASKS)
        .mapToObj(MyTask::new)
        .collect(toList());
}

static void main(String[] argv) {
    runOneShotTasks(makeTasks());
    runCyclicTasks(makeTasks(), sITERATIONS);
}
```
Test Driver Program Walkthrough

• Main entry point into the test program

```java
private static List<MyTask> makeTasks() {
    return IntStream
        .rangeClosed(1, sNUMBER_OF_TASKS)
        .mapToObj(MyTask::new)
        .collect(toList());
}

static void main(String[] argv) {
    runOneShotTasks(makeTasks());
    runCyclicTasks(makeTasks(), sITERATIONS);
}
```

A factory method that makes a list of MyTask objects

However, the details of what MyTask does are not important for our discussion.
private static List<MyTask> makeTasks() {
    return IntStream
        .rangeClosed(1, sNUMBER_OF_TASKS)
        .mapToObj(MyTask::new)
        .collect(toList());
}

static void main(String[] argv) {
    runOneShotTasks(makeTasks());

    runCyclicTasks(makeTasks(), sITERATIONS);
}
Test Driver Program Walkthrough

• Main entry point into the test program

```java
private static List<MyTask> makeTasks() {
    return IntStream
        .rangeClosed(1, sNUMBER_OF_TASKS)
        .mapToObj(MyTask::new)
        .collect(toList());
}

static void main(String[] argv) {
    runOneShotTasks(makeTasks());
    runCyclicTasks(makeTasks(), sITERATIONS);
}
```

Create a new MyTask object for each number in the stream
Test Driver Program Walkthrough

- Main entry point into the test program

```java
private static List<MyTask> makeTasks() {
    return IntStream
        .rangeClosed(1, sNUMBER_OF_TASKS)
        .mapToObj(MyTask::new)
        .collect(toList());
}

static void main(String[] argv) {
    runOneShotTasks(makeTasks());
    runCyclicTasks(makeTasks(), sITERATIONS);
}
```

- Convert the stream into a list of MyTask objects
Main entry point into the test program

```java
private static List<MyTask> makeTasks() {
    return IntStream
        .rangeClosed(1, sNUMBER_OF_TASKS)
        .mapToObj(MyTask::new)
        .collect(toList());
}

static void main(String[] argv) {
    runOneShotTasks(makeTasks());
    runCyclicTasks(makeTasks(), sITERATIONS);
}
```

Run a test showcasing one-shot Phasers used to run a list of tasks that all start at the same time

This method uses Phasers as an “entry barrier” & “exit barrier”
Test Driver Program Walkthrough

• Main entry point into the test program

```java
private static List<MyTask> makeTasks() {
    return IntStream
        .rangeClosed(1, sNUMBER_OF_TASKS)
        .mapToObj(MyTask::new)
        .collect(toList());
}

static void main(String[] argv) {
    runOneShotTasks(makeTasks());
    runCyclicTasks(makeTasks(), sITERATIONS);
}
```

Run a test that showcases a cyclic Phaser that repeatedly performs actions for a given # of iterations
Applying a One-shot Phaser with Java
Applying a One-shot Phaser with Java

• Shows one-shot Phasers that start running a list of tasks simultaneously

```java
void runOneShotTasks(List<MyTask> tasks) {
    Phaser entryPhaser = new Phaser(1);
    Phaser exitPhaser = new Phaser(tasks.size());

    tasks.forEach(task -> {
        entryPhaser.register();

        new Thread(() -> {
            entryPhaser.arriveAndAwaitAdvance();

            task.run();
            exitPhaser.arrive();
        }).start();
    });

    entryPhaser.arriveAndDeregister();
    exitPhaser.awaitAdvance(0);
}
```

See [github.com/douglascairnschmidt/LiveLessons/tree/master/Java8/ex26](https://github.com/douglascairnschmidt/LiveLessons/tree/master/Java8/ex26)
Applying a One-shot Phaser with Java

- Shows one-shot Phasers that start running a list of tasks simultaneously

```java
void runOneShotTasks(List<MyTask> tasks) {
    Phaser entryPhaser = new Phaser(1);
    Phaser exitPhaser = new Phaser(tasks.size());

    tasks.forEach(task -> {
        entryPhaser.register();

        new Thread(() -> {
            entryPhaser.arriveAndAwaitAdvance();

            task.run();
            exitPhaser.arrive();
        }).start();
    });

    entryPhaser.arriveAndDeregister();
    exitPhaser.awaitAdvance(0);
}
```

This “entry barrier” Phaser is similar to a CyclicBarrier (but more flexible)
Applying a One-shot Phaser with Java

- Shows one-shot Phasers that start running a list of tasks simultaneously

```java
void runOneShotTasks(List<MyTask> tasks) {
    Phaser entryPhaser = new Phaser(1);
    Phaser exitPhaser = new Phaser(tasks.size());

    tasks.forEach(task -> {
        entryPhaser.register();

        new Thread(() -> {
            entryPhaser.arriveAndAwaitAdvance();

            task.run();
            exitPhaser.arrive();
        }).start();
    });

    entryPhaser.arriveAndDeregister();
    exitPhaser.awaitAdvance(0);
}
```

Exit barrier w/a “parties” value for all the tasks

This “exit barrier” Phaser is similar to a CountDownLatch (but more flexible)
void runOneShotTasks(List<MyTask> tasks) {
    Phaser entryPhaser = new Phaser(1);
    Phaser exitPhaser = new Phaser(tasks.size());

    tasks.forEach(task -> {
        entryPhaser.register();
        new Thread(() -> {
            entryPhaser.arriveAndAwaitAdvance();
            task.run();
            exitPhaser.arrive();
        }).start();
    });

    entryPhaser.arriveAndDeregister();
    exitPhaser.awaitAdvance(0);
}
Applying a One-shot Phaser with Java

- Shows one-shot Phasers that start running a list of tasks simultaneously

```java
void runOneShotTasks(List<MyTask> tasks) {
    Phaser entryPhaser = new Phaser(1);
    Phaser exitPhaser = new Phaser(tasks.size());

    tasks.forEach(task -> {
        entryPhaser.register();

        new Thread(() -> {
            entryPhaser.arriveAndAwaitAdvance();

            task.run();
            exitPhaser.arrive();
        }).start();
    });

    entryPhaser.arriveAndDeregister();
    exitPhaser.awaitAdvance(0);
}
```

This capability is not available with a CyclicBarrier.
Applying a One-shot Phaser with Java

- Shows one-shot Phasers that start running a list of tasks simultaneously

```java
void runOneShotTasks(List<MyTask> tasks) {
    Phaser entryPhaser = new Phaser(1);
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    tasks.forEach(task -> {
        entryPhaser.register();

        new Thread() -> {
            entryPhaser.arriveAndAwaitAdvance();
            task.run();
            exitPhaser.arrive();
        }.start();
    });

    entryPhaser.arriveAndDeregister();
    exitPhaser.awaitAdvance(0);
}
```

Create/start a new worker thread that runs the task once other threads arrive
Applying a One-shot Phaser with Java

- Shows one-shot Phasers that start running a list of tasks simultaneously

```java
void runOneShotTasks(List<MyTask> tasks) {
    Phaser entryPhaser = new Phaser(1);
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    tasks.forEach(task -> {
        entryPhaser.register();
        new Thread(() -> {
            entryPhaser.arriveAndAwaitAdvance();

            task.run();
            exitPhaser.arrive();
        }).start();
    });

    entryPhaser.arriveAndDeregister();
    exitPhaser.awaitAdvance(0);
}
```

- Phaser.arriveAndAwaitAdvance() is similar to CyclicBarrier.await()
- Block until all worker threads have started
Applying a One-shot Phaser with Java

• Shows one-shot Phasers that start running a list of tasks simultaneously

```java
void runOneShotTasks(List<MyTask> tasks) {
    Phaser entryPhaser = new Phaser(1);
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    tasks.forEach(task -> {
        entryPhaser.register();

        new Thread(() -> {
            entryPhaser.arriveAndAwaitAdvance();

            task.run();
            exitPhaser.arrive();
        }).start();
    });

    entryPhaser.arriveAndDeregister();
    exitPhaser.awaitAdvance(0);
}
```

This code uses entryPhaser as a one-shot “entry barrier”
Applying a One-shot Phaser with Java

- Shows one-shot Phasers that start running a list of tasks simultaneously

```java
void runOneShotTasks(List<MyTask> tasks) {
    Phaser entryPhaser = new Phaser(1);
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    tasks.forEach(task -> {
        entryPhaser.register();

        new Thread(() -> {
            entryPhaser.arriveAndAwaitAdvance();
            task.run();
            exitPhaser.arrive();
        }).start();
    });

    entryPhaser.arriveAndDeregister();
    exitPhaser.awaitAdvance(0);
}
```

Run the task → task.run();

The details of what MyTask does are not important for our discussion.
Applying a One-shot Phaser with Java

• Shows one-shot Phasers that start running a list of tasks simultaneously

```java
void runOneShotTasks(List<MyTask> tasks) {
    Phaser entryPhaser = new Phaser(1);
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    tasks.forEach(task -> {
        entryPhaser.register();

        new Thread(() -> {
            entryPhaser.arriveAndAwaitAdvance();

            task.run();

            exitPhaser.arrive();
        }).start();
    });

    entryPhaser.arriveAndDeregister();
    exitPhaser.awaitAdvance(0);
}
```

*Phaser.arrive() is used similarly to CountDownLatch.countdown() here*
void runOneShotTasks(List<MyTask> tasks) {
    Phaser entryPhaser = new Phaser(1);
    Phaser exitPhaser = new Phaser(tasks.size());

    tasks.forEach(task -> {
        entryPhaser.register();

        new Thread(() -> {
            entryPhaser.arriveAndAwaitAdvance();

            task.run();
            exitPhaser.arrive();
        }).start();
    });

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}
Applying a One-shot Phaser with Java

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```java
void runOneShotTasks(List<MyTask> tasks) {
    Phaser entryPhaser = new Phaser(1);
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    tasks.forEach(task -> {
        entryPhaser.register();

        new Thread(() -> {
            entryPhaser.arriveAndAwaitAdvance();
            task.run();
            exitPhaser.arrive();
        }).start();
    });

    entryPhaser.arriveAndDeregister();
    exitPhaser.awaitAdvance(0);
}
```

Phaser.awaitAdvance() is used similarly to CountDownLatch.await() here.
Applying a Cyclic Phaser with Java
Applying Cyclic Phaser with Java

- A cyclic Phaser that repeatedly performs actions for a given # of iterations

```java
void runCyclicTasks(List<MyTask> tasks, int iterations) {
    Phaser phaser = new Phaser() {
        protected boolean onAdvance(int phase, int regParties) {
            return (phase + 1) == iterations || regParties == 0;
        }
    };

    phaser.bulkRegister(1 + tasks.size());

    tasks.forEach(task -> {
        new Thread(() -> {
            do {
                task.run();
                phaser.arriveAndAwaitAdvance();
            } while (!phaser.isTerminated());
        }).start();
    });

    while (!phaser.isTerminated()) phaser.arriveAndAwaitAdvance();
}
```

See [github.com/douglascraigschmidt/LiveLessons/tree/master/Java8/ex26](https://github.com/douglascraigschmidt/LiveLessons/tree/master/Java8/ex26)
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        protected boolean onAdvance(int phase, int regParties) {
            return (phase + 1) == iterations || regParties == 0;
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    };

    phaser.bulkRegister(1 + tasks.size());

    tasks.forEach(task -> { new Thread() -> {
        do {
            task.run();
            phaser.arriveAndAwaitAdvance();
        } while (!phaser.isTerminated());
    }).start();

    while (!phaser.isTerminated()) phaser.arriveAndAwaitAdvance();
}
```

Create a phaser that runs a given # of times

See github.com/douglascraigschmidt/LiveLessons/tree/master/Java8/ex26
Applying Cyclic Phaser with Java

- A cyclic Phaser that repeatedly performs actions for a given # of iterations

```java
void runCyclicTasks(List<MyTask> tasks, int iterations) {
    Phaser phaser = new Phaser() {
        protected boolean onAdvance(int phase, int regParties) {
            return (phase + 1) == iterations || regParties == 0;
        }
    };
    phaser.bulkRegister(1 + tasks.size());
    tasks.forEach(task -> { new Thread() -> {
        do {
            task.run();
            phaser.arriveAndAwaitAdvance();
        } while (!phaser.isTerminated());
    }).start();
    while (!phaser.isTerminated()) phaser.arriveAndAwaitAdvance();
}
```

Determine when to terminate phaser

`onAdvance()` is a hook method
Applying Cyclic Phaser with Java

- A cyclic Phaser that repeatedly performs actions for a given # of iterations

```java
void runCyclicTasks(List<MyTask> tasks, int iterations) {
    Phaser phaser = new Phaser() {
        protected boolean onAdvance(int phase, int regParties) {
            return (phase + 1) == iterations || regParties == 0;
        }
    };
    phaser.bulkRegister(1 + tasks.size());
    tasks.forEach(task -> { new Thread(() -> {
        do {
            task.run();
            phaser.arriveAndAwaitAdvance();
        } while (!phaser.isTerminated());
    }).start();
    }
    while (!phaser.isTerminated()) phaser.arriveAndAwaitAdvance();
}
```

Terminates when all iterations have completed or all parties are done
Applying Cyclic Phaser with Java

• A cyclic Phaser that repeatedly performs actions for a given # of iterations

```java
void runCyclicTasks(List<MyTask> tasks, int iterations) {
    Phaser phaser = new Phaser()
    protected boolean onAdvance(int phase,
        int regParties) {
        return (phase + 1) == iterations || regParties == 0;
    });
    phaser.bulkRegister(1 + tasks.size());
    tasks.forEach(task -> { new Thread() -> {
        do {
            task.run();
            phaser.arriveAndAwaitAdvance();
        } while (!phaser.isTerminated());
    }).start();
    while (!phaser.isTerminated()) phaser.arriveAndAwaitAdvance();
}
```

Phaser.bulkRegister() is used in lieu of registering each task in forEach()
A cyclic Phaser that repeatedly performs actions for a given # of iterations

```java
void runCyclicTasks(List<MyTask> tasks, int iterations) {
    Phaser phaser = new Phaser() {
        protected boolean onAdvance(int phase, int regParties) {
            return (phase + 1) == iterations || regParties == 0;
        }
    };

    phaser.bulkRegister(1 + tasks.size());

    tasks.forEach(task -> { new Thread(() -> {
        do {
            task.run();
            phaser.arriveAndAwaitAdvance();
        } while (!phaser.isTerminated());
    }).start();

    while (!phaser.isTerminated()) phaser.arriveAndAwaitAdvance();
}
```

Iterate thru all the tasks
Applying Cyclic Phaser with Java

- A cyclic Phaser that repeatedly performs actions for a given # of iterations

```java
void runCyclicTasks(List<MyTask> tasks, int iterations) {
    Phaser phaser = new Phaser() {
        protected boolean onAdvance(int phase, int regParties) {
            return (phase + 1) == iterations || regParties == 0;
        }
    };

    phaser.bulkRegister(1 + tasks.size());

    tasks.forEach(task -> {
        new Thread() -> {
            do {
                task.run();
                phaser.arriveAndAwaitAdvance();
            } while (!phaser.isTerminated());
        }).start();
    });

    while (!phaser.isTerminated()) phaser.arriveAndAwaitAdvance();
}
```

Create/start a worker thread
Applying Cyclic Phaser with Java

- A cyclic Phaser that repeatedly performs actions for a given # of iterations

```java
void runCyclicTasks(List<MyTask> tasks, int iterations) {
    Phaser phaser = new Phaser() {
        protected boolean onAdvance(int phase, int regParties) {
            return (phase + 1) == iterations || regParties == 0;
        }
    };

    phaser.bulkRegister(1 + tasks.size());

    tasks.forEach(task -> {
        new Thread() -> {
            do {
                task.run();
                phaser.arriveAndAwaitAdvance();
            } while (!phaser.isTerminated());
        }).start();
    });

    while (!phaser.isTerminated()) phaser.arriveAndAwaitAdvance();
}
```

Run the task

The details of what MyTask does are not important for our discussion
Applying Cyclic Phaser with Java

- A cyclic Phaser that repeatedly performs actions for a given # of iterations

```java
void runCyclicTasks(List<MyTask> tasks, int iterations) {
    Phaser phaser = new Phaser() {
        protected boolean onAdvance(int phase, int regParties) {
            return (phase + 1) == iterations || regParties == 0;
        }
    };

    phaser.bulkRegister(1 + tasks.size());

    tasks.forEach(task -> { new Thread(() -> {
        do {
            task.run();
            phaser.arriveAndAwaitAdvance();
        } while (!phaser.isTerminated());
    }).start();
});

    while (!phaser.isTerminated()) phaser.arriveAndAwaitAdvance();
}
```

Block until all the other threads/tasks complete this phase
A cyclic Phaser that repeatedly performs actions for a given # of iterations

```java
void runCyclicTasks(List<MyTask> tasks, int iterations) {
    Phaser phaser = new Phaser() {
        protected boolean onAdvance(int phase, int regParties) {
            return (phase + 1) == iterations || regParties == 0;
        }
    };
    phaser.bulkRegister(1 + tasks.size());
    tasks.forEach(task -> { new Thread(() -> {
        do {
            task.run();
            phaser.arriveAndAwaitAdvance();
        } while (!phaser.isTerminated());
    }).start();
    });
    while (!phaser.isTerminated()) phaser.arriveAndAwaitAdvance();
}
```

This code is using the phaser as a “cyclic exit barrier”
Applying Cyclic Phaser with Java

- A cyclic Phaser that repeatedly performs actions for a given # of iterations

```java
void runCyclicTasks(List<MyTask> tasks, int iterations) {
    Phaser phaser = new Phaser() {
        protected boolean onAdvance(int phase, int regParties) {
            return (phase + 1) == iterations || regParties == 0;
        }
    }
    phaser.bulkRegister(1 + tasks.size());
    tasks.forEach(task -> { new Thread(() -> {
        do {
            task.run();
            phaser.arriveAndAwaitAdvance();
        } while (!phaser.isTerminated());
    }).start();
    });
    while (!phaser.isTerminated()) phaser.arriveAndAwaitAdvance();
}
```

The last thread to arrive at the end of a phase triggers a call to the `onAdvance()` hook method.
A cyclic Phaser that repeatedly performs actions for a given number of iterations.

```java
class CyclicPhaserExample {
    public static void main(String[] args) {
        List<MyTask> tasks = new ArrayList<>();
        tasks.add(new MyTask());
        tasks.add(new MyTask());
        tasks.add(new MyTask());

        Phaser phaser = new Phaser();
        phaser.bulkRegister(1 + tasks.size());

        tasks.forEach(task -> {
            Thread thread = new Thread(() -> {
                while (!phaser.isTerminated()) {
                    task.run();
                    phaser.arriveAndAwaitAdvance();
                }
            });
            thread.start();
        });

        while (!phaser.isTerminated()) {
            phaser.arriveAndAwaitAdvance();
        }
    }
}
```

Terminate when the phase number + 1 equals the iterations.
Applying Cyclic Phaser with Java

- A cyclic Phaser that repeatedly performs actions for a given # of iterations

```java
void runCyclicTasks(List<MyTask> tasks, int iterations) {
    Phaser phaser = new Phaser() {
        protected boolean onAdvance(int phase, int regParties) {
            return (phase + 1) == iterations || regParties == 0;
        }
    };

    phaser.bulkRegister(1 + tasks.size());

    tasks.forEach(task -> { new Thread() -> {
        do {
            task.run();
            phaser.arriveAndAwaitAdvance();
        } while (!phaser.isTerminated());
    }).start();
}
```

Threads loop until they are terminated by onAdvance()
Applying Cyclic Phaser with Java

- A cyclic Phaser that repeatedly performs actions for a given # of iterations

```java
void runCyclicTasks(List<MyTask> tasks, int iterations) {
    Phaser phaser = new Phaser() {
        protected boolean onAdvance(int phase, int regParties) {
            return (phase + 1) == iterations || regParties == 0;
        }
    };

    phaser.bulkRegister(1 + tasks.size());

    tasks.forEach(task -> { new Thread(() -> {
        do {
            task.run();
            phaser.arriveAndAwaitAdvance();
        } while (!phaser.isTerminated());
    }).start();
    });

    while (!phaser.isTerminated()) phaser.arriveAndAwaitAdvance();
}
```

Calling thread loops until terminated by `onAdvance()`

arriveAndAwaitAdvance() blocks waiting the end of each phase, so this loop does not “busy wait”
End of Example Application of Java Phaser