76% completed

Search Course

Multithreading in Java

Java's Memory Model

Interview Practice Problems

Bonus Questions

- Ordered Printing
- Printing Foo Bar n Times
- Printing Number Series (Zero, Even, Odd)
- Build a Molecule
- Fizz Buzz Problem

Beyond the Interview

Java Concurrency

Practice Mock Interview →

Java Multithreading for Senior Engineering Interviews / ... / Printing Number Series (Zero, Even, Odd)

Printing Number Series (Zero, Even, Odd)

This problem is about repeatedly executing threads which print a specific type of number. Another variation of this problem; print even and odd numbers; utilizes two threads instead of three.

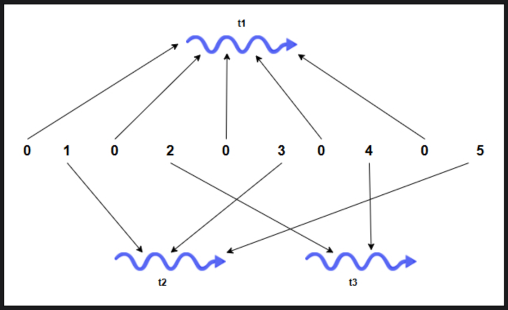
Problem Statement

Suppose we are given a number _n_based on which a program creates the series *010203…0n*. There are three threads t1, t2 and t3 which print a specific type of number from the series. t1 only prints zeros, t2 prints odd numbers and t3 prints even numbers from the series. The code for the class is given as follows:

```
class PrintNumberSeries {

    public PrintNumberSeries(int n) {
    |   this.n = n;
    }

    public void PrintZero() {
    }
    public void PrintOdd() {
    }
    public void PrintEven() {
    }

}
```

You are required to write a program which takes a user input n and outputs the number series using three threads. The three threads work together to print zero, even and odd numbers. The threads should be synchronized so that the functions PrintZero(), PrintOdd() and PrintEven() are executed in an order.

The workflow of the program is shown below:



Solution

This problem is solved by using Semaphores in Java. Semaphores are used to restrict the number of threads that can access some (physical or logical) resource at the same time. Our solution makes use of three semaphores; `zeroSem` for printing zeros, `oddSem` for printing odd numbers and `evenSem` for printing even numbers. The basic structure of the class is given below:

```
class PrintNumberSeries {

    private int n;
    private Semaphore zeroSem, oddSem, evenSem;

    public PrintNumberSeries(int n) {
    }

    public void PrintZero() {
    }

    public void PrintOdd() {
    }

    public void PrintEven() {
    }

}
```

`n` is the user input that prints the series till *n* th number. The constructor of this class appears below:

```
public PrintNumberSeries(int n) {
    |   this.n = n;
    |   zeroSem = new Semaphore(1);
    |   oddSem = new Semaphore(0);
    |   evenSem = new Semaphore(0);
}
```

The argument passed to semaphore's constructor is the number of 'permits' available. For `oddSem` and `evenSem`, all `acquire()` calls will be blocked initially as they are initialized with 0. For `zeroSem`, the first `acquire()` call will succeed as it is intialized with 1. The code of the first method PrintZero() is as follows:

```
1. public void PrintZero() {
2.     for (int i = 0; i < n; ++i) {
3.         zeroSem.acquire();
4.         System.out.print("0");
5.         // release oddSem if i is even else release evenSem if i is odd
6.         (i % 2 == 0 ? oddSem : evenSem).release();
7.     }
8.}
```

PrintZero() begins with a loop iterating from 0 till n (exclusive). The semaphore zeroSem is acquired and '0' is printed. A very significant line in this method is **line 6** in the loop. The modulus operator (%) gives the remainder of a division by the value following it. In our case, the current value is divided by 2 to determine if i is even or odd. If i is odd, then it means we just printed an odd number and the next number in the sequence will be an even number so, evenSem is released. In the same way if i is even then oddSem is released for printing the next odd number in the sequence. The second method PrintOdd() is shown below:

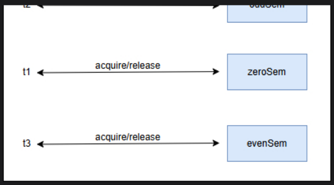
```
public void PrintOdd() {
    for (int i = 1; i <= n; i += 2) {
        oddSem.acquire();
        System.out.print(i);
        zeroSem.release();
    }
}
```

The loop iterates from 1 till n (inclusive) and i is incremented by 2 after each iteration to ensure that only odd numbers are printed. oddSem is acquired when PrintZero() releases it after determining that it is the turn for an odd number to be printed. Since zero is required to be printed before every even or odd number, zeroSem is released after printing the odd number.

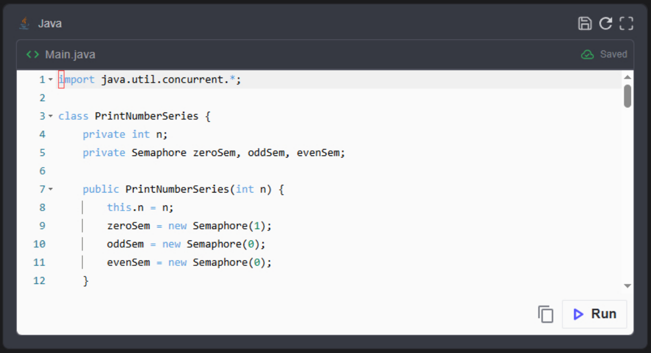
The last method of the class PrintEven() is shown below:

```
public void PrintEven() {
    for (int i = 2; i <= n; i += 2) {
        evenSem.acquire();
        System.out.print(i);
        zeroSem.release();
    }
}
```

PrintEven() operates in the same manner as PrintOdd() except that its loop begins from 2. evenSem is acquired if it is released by PrintZero() and an even number is printed. zeroSem is released for zero to be printed next. If n is reached, the loop breaks. The working of this class can be seen as a lock-shift phenomenon where every method is given the control at its turn and blocked otherwise. n is manipulated by only one thread at a time.



To test our solution, We will create 3 threads t1, t2 and t3 in Main class. t1 prints 0, t2 prints odd numbers and t3 prints even numbers. The threads are started in random order.



```
import java.util.concurrent.*;

class PrintNumberSeries {
    private int n;
    private Semaphore zeroSem, oddSem, evenSem;

    public PrintNumberSeries(int n) {
        this.n = n;
        zeroSem = new Semaphore(1);
        oddSem = new Semaphore(0);
        evenSem = new Semaphore(0);
    }
```

We were told to use three threads in the problem statement but the solution can be achieved using two threads as well. Since zero is printed before every number, we do not need to dedicate a special thread for it. We can simply print a zero before printing every odd or even number.

← Back lesson
Printing Foo Bar n Times

☑ Completed

Next →
Build a Molecule

[redacted]