



Module 03 – Piscine Java

Threads

Summary: Today you will learn how to use basic multithreading mechanisms in Java

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Chapter I

Foreword

- Any up-to-date client/server application is based on threads.
- Threads implement the asynchronous operation concept, where several loosely-coupled tasks are performed "in parallel."
- Multithreading in client/server applications enables to put some tasks into background execution mode so that client does not have to wait for server's response. For example, once you have specified your email on the website, a page is displayed immediately to inform that the confirmation message has been sent to your email address regardless of how long it will take to send the message to your email in a parallel thread.
- Each of your requests on a website is performed in an individual, independent thread on the server.
- Behavior of threads is managed by the operating system and the processor.
- Behavior of threads is non-deterministic. You never know which thread will run at a specific moment, even if you restart the same multithreaded code.
- Tips on handling threads can be found in Object class.
- Threads are the favorite topic in junior interviews.

Chapter II


Instructions

- Use this page as the only reference. Do not listen to any rumors and speculations about how to prepare your solution.
- Now there is only one Java version for you, 1.8. Make sure that compiler and interpreter of this version are installed on your machine.
- You can use IDE to write and debug the source code.
- The code is read more often than written. Read carefully the [document](#) where code formatting rules are given. When performing each task, make sure you follow the generally accepted [Oracle standards](#)
- Comments are not allowed in the source code of your solution. They make it difficult to read the code.
- Pay attention to the permissions of your files and directories.
- To be assessed, your solution must be in your GIT repository.
- Your solutions will be evaluated by your piscine mates.
- You should not leave in your directory any other file than those explicitly specified by the exercise instructions. It is recommended that you modify your .gitignore to avoid accidents.
- When you need to get precise output in your programs, it is forbidden to display a precalculated output instead of performing the exercise correctly.
- Have a question? Ask your neighbor on the right. Otherwise, try with your neighbor on the left.
- Your reference manual: mates / Internet / Google. And one more thing. There's an answer to any question you may have on Stackoverflow. Learn how to ask questions correctly.
- Read the examples carefully. They may require things that are not otherwise specified in the subject.
- And may the Force be with you!

- Never leave that till tomorrow which you can do today ;)

Chapter III

Exercise 00 : Egg, Hen... or Human?

	Exercise 00
Egg, Hen... or Human?	
Turn-in directory : <i>ex00/</i>	
Files to turn in : *.java	
Allowed functions : Object, Thread, Runnable	

The truth is born in a dispute—let's assume that each thread provides its own answer. The thread that has the last word is right.

You need to implement the operation of two threads. Each of them must display its answer a few times, for example, 50:

```
$ java Program --count=50
Egg
Hen
Hen
Hen
...
Egg
```


In this case, the egg thread wins. However, the program also contains main thread. Inside the thread, `public static void main(String args[])` method is executed. We need this thread to display all its responses at the end of program execution. Thus, the ultimate variant is as follows:

```
$ java Program --count=50
Egg
Hen
Hen
...
Egg
Hen
...
Human
...
...
Human
```

- It means that the program outputs Human message 50 times, which main thread prints.

Chapter IV

Exercise 01 : Egg, Hen, Egg, Hen...

	Exercise 01
Egg, Hen, Egg, Hen...	
Turn-in directory : <i>ex01/</i>	
Files to turn in : *.java	
Allowed functions : Object, Thread, Runnable, Synchronized	

Let's orchestrate the argument. Now, each thread can provide its answer only after another thread has done so. Let's assume that the egg thread always answers first.


```
$ java Program --count=50
Egg
Hen
Egg
Hen
Egg
Hen
...
```

Note:

- To solve this task, we recommend to explore Producer-Consumer model operation principle

Chapter V

Exercise 02 : Real Multithreading

	Exercise 02
	Real Multithreading
	Turn-in directory : <i>ex02/</i>
	Files to turn in : *.java
	Allowed functions : Object, Thread, Runnable, Synchronized

Try to use multithreading for its intended purpose: distribute computations across the program.

Let's assume there is an array of integer values. Your goal is to calculate the sum of array elements using several "summing" threads. Each thread computes a certain section inside the array. The number of elements in each section is constant, except for the last one (its size can differ upward or downward).

The array shall be randomly generated each time. Array length and the number of threads are passed as command-line arguments.

To make sure the program operates correctly, we should start by calculating the sum of array elements using a standard method.

Maximum number of array elements is 2,000,000. Maximum number of threads is no greater than current number of array elements. Maximum modulo value of each array element is 1,000. All data is guaranteed to be valid.

Example of the program operation (each array element equals 1):


```
$ java Program --arraySize=13 --threadsCount=3
Sum: 13
Thread 1: from 0 to 4 sum is 5
Thread 2: from 5 to 9 sum is 5
Thread 3: from 10 to 12 sum is 3
Sum by threads: 13
```

Note:

- In the above example, the size of the last summing-up section used by the third thread is less than others.
- Threads can output the results of operation inconsistently.

Chapter VI

Exercise 03 : Too Many Threads...

	Exercise 03
Too Many Threads...	
Turn-in directory : <i>ex03/</i>	
Files to turn in : *.java	
Allowed functions : Object, Thread, Runnable, Synchronized	

Let's assume that we need to download a list of files from a network. Some files are downloaded faster, while others are slower.

To implement this functionality, we can obviously use multithreaded downloading where each thread loads a specific file. But what should we do if there are too many files? A large number of threads cannot be run at the same time. Therefore, many of them will be waiting.

In addition, we should bear in mind that continuously creating and completing threads is a very costly operation we should avoid. It makes more sense to start N threads at once and, when either of them finishes downloading the file, it can take on the next file in the queue.

We need to create `files_urls.txt` file (file name shall be explicitly specified in program code) where you specify a list of URLs of files to be downloaded, for instance:

```
1 https://i.pinimg.com/originals/11/19/2e/11192eba63f6f3aa591d3263fdb66bd5.jpg
2 https://pluspng.com/img-png/balloon-hd-png-balloons-png-hd-2750.png
3 https://i.pinimg.com/originals/db/a1/62/dba162603c71cac00d3548420c52bac6.png
4 https://pngimg.com/uploads/balloon/balloon_PNG4969.png
5 http://tldp.org/LDP/intro-linux/intro-linux.pdf
```

Example of program operation:

```
$ java Program.java --threadsCount=3
Thread-1 start download file number 1
Thread-2 start download file number 2
```

```
Thread-1 finish download file number 1
Thread-1 start download file number 3
Thread-3 start download file number 4
Thread-1 finish download file number 3
Thread-2 finish download file number 2
Thread-1 start download file number 5
Thread-3 finish download file number 4
Thread-1 finish download file number 5
```

Notes:

- Output created by the implemented program may differ from the illustration.
- Each file is downloaded only once by a single thread.
- The program may contain an "infinite loop" without the exit condition (in this case, the program can be shut down by interrupting the process).