Year/2022

Course Code:1DV512

Assignment#:3

Name: Yetnayet Belachew(yb222ce)

Report

Multithreading Servive

The scheduler was implemented in java. The basic requirement was to simulate tasks using multithreading. The later describes the strategies used and how was output obtained from the implementation.

Q.1 What strategy have you chosen for implementing tasks and their multithreaded execution? Have you considered any alternatives? How have you handled the termination of threads on simulation finish (when the simulation time runs out)?

A java class Task was made with Runnable interface to implement threads.

Thread pool was used to create a pool of number of threads required using ExecutorService and Executors.newFixedThreadPool(int). Thirty tasks were created and were assigned sequentially to 4 threads created in Thread pool.

3 simulations for 15 seconds each were run, and results were obtained. No other alternatives were considered. A check was kept ensuring that simulation take 15 seconds and not more than that.

To stop the executor of thread, shutdownNow () function was used which is predefined for executor.

Three integer arraylists are declared completed (for task ids of completed tasks), interrupted (for task ids of interrupted tasks) and waiting (for the tasks waiting for CPU).

Q.2 Based on the simulations that you have witnessed, are all the tasks completed during the simulation time? How many are reported incomplete/interrupted and waiting/non-scheduled?

Not all tasks were completed because 4 threads were used to run tasks. Tasks were assigned sequentially to threads and these tasks were run according to their sequential order due to which

not all of them were able to get CPU. In all iteration 4 tasks were interrupted. This resulted in some takes waiting for CPU while some were finished. Details of which can be seen in screenshots from output of the code. Following table summarizes the status of tasks for 3 simulations.

	Completed	Interrupted	Incomplete
1	9	4	17
2	11	4	15
3	15	4	11

Q.3 What information has the output of jstack provided to you with regard to the threads in your Java program implementation?

JPS command along with Jstack command were used to get the process id of currently running java program and thread trace. The thread dump showed some system threads used by program itself along with the user created threads inside the program.4 threads were created, and dump showed all 4 threads used in program with thread ids 1,2,3,4.

Following from next page are screen shots of program output and thread dump from command prompt

```
Running simulation #0
Simulation results:
----------------------
completed tasks :
ID        burst   Start                           finish

0         8000    04:52:53.265464800              04:53:02.062808
1         6000    04:52:53.265464800              04:52:59.866119900
2         5000    04:52:53.265464800              04:52:58.767942800
3         6000    04:52:53.265464800              04:52:59.866119900
4         4000    04:52:58.767942800              04:53:03.159828700
5         3000    04:52:59.866119900              04:53:03.159828700
6         3000    04:52:59.866119900              04:53:03.159828700
9         4000    04:53:03.159828700              04:53:07.568316100
10        4000    04:53:03.159828700              04:53:07.568316100

interrupted tasks:
ID        7
ID        8
ID        11
ID        12
```

```
waiting tasks:
ID        13
ID        14
ID        15
ID        16
ID        17
ID        18
ID        19
ID        20
ID        21
ID        22
ID        23
ID        24
ID        25
ID        26
ID        27
ID        28
ID        29
```

```
Running simulation #1
Simulation results:
----------------------
completed tasks :
ID        burst   Start                       finish

0         6000    04:53:08.270999500          04:53:15.042126300
1         1000    04:53:08.270999500          04:53:09.366790100
2         3000    04:53:08.270999500          04:53:11.557961500
3         9000    04:53:08.288999700          04:53:18.511436300
4         2000    04:53:09.366790100          04:53:11.557961500
5         4000    04:53:11.557961500          04:53:16.150115
6         8000    04:53:11.557961500          04:53:20.733234400
7         4000    04:53:15.043131700          04:53:19.610246800
10        2000    04:53:19.610246800          04:53:21.908223300
11        2000    04:53:20.735231400          04:53:23.102203900
12        1000    04:53:21.912217800          04:53:23.105201700

interrupted tasks:
ID        8
ID        9
ID        13
ID        14

waiting tasks:
ID        15
ID        16
ID        17
ID        18
ID        19
ID        20
ID        21
ID        22
ID        23
ID        24
ID        25
ID        26
ID        27
ID        28
ID        29
```

```
Running simulation #2
Simulation results:
---------------------
completed tasks :
ID      burst   Start                          finish

0       2000    04:53:23.343204300      04:53:25.538172800
1       1000    04:53:23.343204300      04:53:24.445187600
2       3000    04:53:23.343204300      04:53:26.626836200
3       2000    04:53:23.343204300      04:53:25.543175300
4       3000    04:53:24.445187600      04:53:27.756712300
5       1000    04:53:25.543175300      04:53:26.626836200
6       1000    04:53:25.543175300      04:53:26.626836200
7       3000    04:53:26.626836200      04:53:29.940085100
8       5000    04:53:26.626836200      04:53:32.120932100
9       6000    04:53:26.626836200      04:53:33.225252300
10      8000    04:53:27.762735300      04:53:36.525765300
11      1000    04:53:29.940085100       04:53:31.038577
12      3000    04:53:31.038577 04:53:34.323751900
13      1000    04:53:32.120932100      04:53:33.209208700
15      3000    04:53:33.225252300      04:53:36.525765300

interrupted tasks:
ID      14
ID      16
ID      17
ID      18
```

```
waiting tasks:
ID        19
ID        20
ID        21
ID        22
ID        23
ID        24
ID        25
ID        26
ID        27
ID        28
ID        29


----------------------
Exiting...
```

Screenshots of command thread dump for Multithreaded Service

Administrator: Command Prompt

C:\Windows\system32>jps
1680 Jps
2192 MultithreadedService
7924
4392 Launcher

C:\Windows\system32>jstack 2192
2021-06-03 23:19:08
Full thread dump Java HotSpot(TM) 64-Bit Server VM (16.0.1+9-24 mixed mode, sharing):

Threads class SMR info:
_java_thread_list=0x000001822e281490, length=17, elements={
0x000001820debd1e0, 0x000001822d53a630, 0x000001822d53d500, 0x000001822d54aed0,
0x000001822d54e9f0, 0x000001822d54fb90, 0x000001822d5534f0, 0x000001822d5557b0,
0x000001822d5562a0, 0x000001822d5bffd0, 0x000001822e05aef0, 0x000001822e05b990,
0x000001822e05b440, 0x000001822e05bee0, 0x000001822e05c980, 0x000001822e05ced0,
0x000001822e05c430
}

"main" #1 prio=5 os_prio=0 cpu=34656.25ms elapsed=43.69s tid=0x000001820debd1e0 nid=0xad8 runnable [0x0000005f981fe000]
   java.lang.Thread.State: RUNNABLE
        at java.util.concurrent.ThreadPoolExecutor.interruptIdleWorkers(java.base@16.0.1/ThreadPoolExecutor.java:801)
        at java.util.concurrent.ThreadPoolExecutor.interruptIdleWorkers(java.base@16.0.1/ThreadPoolExecutor.java:812)
        at java.util.concurrent.ThreadPoolExecutor.shutdown(java.base@16.0.1/ThreadPoolExecutor.java:1377)
        at MultithreadedService.runNewSimulation(MultithreadedService.java:184)
        at MultithreadedService.main(MultithreadedService.java:255)

"Reference Handler" #2 daemon prio=10 os_prio=2 cpu=0.00ms elapsed=43.11s tid=0x000001822d53a630 nid=0x4a8 waiting on condition [0x0000005f988fe000]
   java.lang.Thread.State: RUNNABLE
        at java.lang.ref.Reference.waitForReferencePendingList(java.base@16.0.1/Native Method)
        at java.lang.ref.Reference.processPendingReferences(java.base@16.0.1/Reference.java:243)
        at java.lang.ref.Reference$ReferenceHandler.run(java.base@16.0.1/Reference.java:215)

"Finalizer" #3 daemon prio=8 os_prio=1 cpu=0.00ms elapsed=43.10s tid=0x000001822d53d500 nid=0x1d8c in Object.wait() [0x0000005f989fe000]
   java.lang.Thread.State: WAITING (on object monitor)
        at java.lang.Object.wait(java.base@16.0.1/Native Method)
        - waiting on <0x0000000081c002e8> (a java.lang.ref.ReferenceQueue$Lock)
        at java.lang.ref.ReferenceQueue.remove(java.base@16.0.1/ReferenceQueue.java:155)
        - locked <0x0000000081c002e8> (a java.lang.ref.ReferenceQueue$Lock)
        at java.lang.ref.ReferenceQueue.remove(java.base@16.0.1/ReferenceQueue.java:176)
        at java.lang.ref.Finalizer$FinalizerThread.run(java.base@16.0.1/Finalizer.java:171)

Administrator: Command Prompt

"Signal Dispatcher" #4 daemon prio=9 os_prio=2 cpu=15.62ms elapsed=43.03s tid=0x000001822d54aed0 nid=0xe44 runnable [0x0000000000000000]
   java.lang.Thread.State: RUNNABLE

"Attach Listener" #5 daemon prio=5 os_prio=2 cpu=187.50ms elapsed=43.03s tid=0x000001822d54e9f0 nid=0x1360 waiting on condition [0x0000000000000000]
   java.lang.Thread.State: RUNNABLE

"Service Thread" #6 daemon prio=9 os_prio=0 cpu=0.00ms elapsed=43.03s tid=0x000001822d54fb90 nid=0x5a0 runnable [0x0000000000000000]
   java.lang.Thread.State: RUNNABLE

"Monitor Deflation Thread" #7 daemon prio=9 os_prio=0 cpu=0.00ms elapsed=43.03s tid=0x000001822d5534f0 nid=0x289c runnable [0x0000000000000000]
   java.lang.Thread.State: RUNNABLE

"C2 CompilerThread0" #8 daemon prio=9 os_prio=2 cpu=1000.00ms elapsed=43.03s tid=0x000001822d5557b0 nid=0x7f8 waiting on condition [0x0000000000000000]
   java.lang.Thread.State: RUNNABLE
   No compile task

"C1 CompilerThread0" #10 daemon prio=9 os_prio=2 cpu=750.00ms elapsed=43.03s tid=0x000001822d5562a0 nid=0xdd0 waiting on condition [0x0000000000000000]
   java.lang.Thread.State: RUNNABLE
   No compile task

"Sweeper thread" #11 daemon prio=9 os_prio=2 cpu=0.00ms elapsed=42.99s tid=0x000001822d5bffd0 nid=0x428 runnable [0x0000000000000000]
   java.lang.Thread.State: RUNNABLE

"Common-Cleaner" #12 daemon prio=8 os_prio=1 cpu=0.00ms elapsed=42.66s tid=0x000001822e05aef0 nid=0x2314 in Object.wait() [0x0000005f991ff000]
   java.lang.Thread.State: TIMED_WAITING (on object monitor)
        at java.lang.Object.wait(java.base@16.0.1/Native Method)
        - waiting on <0x0000000081c00658> (a java.lang.ref.ReferenceQueue$Lock)
        at java.lang.ref.ReferenceQueue.remove(java.base@16.0.1/ReferenceQueue.java:155)
        - locked <0x0000000081c00658> (a java.lang.ref.ReferenceQueue$Lock)
        at jdk.internal.ref.CleanerImpl.run(java.base@16.0.1/CleanerImpl.java:140)
        at java.lang.Thread.run(java.base@16.0.1/Thread.java:831)
        at jdk.internal.misc.InnocuousThread.run(java.base@16.0.1/InnocuousThread.java:134)

"Monitor Ctrl-Break" #13 daemon prio=5 os_prio=0 cpu=62.50ms elapsed=42.23s tid=0x000001822e05b990 nid=0x16a8 runnable [0x0000005f992fe000]
   java.lang.Thread.State: RUNNABLE
        at sun.nio.ch.SocketDispatcher.read0(java.base@16.0.1/Native Method)
        at sun.nio.ch.SocketDispatcher.read(java.base@16.0.1/SocketDispatcher.java:46)
        at sun.nio.ch.NioSocketImpl.tryRead(java.base@16.0.1/NioSocketImpl.java:261)
        at sun.nio.ch.NioSocketImpl.implRead(java.base@16.0.1/NioSocketImpl.java:312)
        at sun.nio.ch.NioSocketImpl.read(java.base@16.0.1/NioSocketImpl.java:350)
        at sun.nio.ch.NioSocketImpl$1.read(java.base@16.0.1/NioSocketImpl.java:803)
        at java.net.Socket$SocketInputStream.read(java.base@16.0.1/Socket.java:976)
        at sun.nio.cs.StreamDecoder.readBytes(java.base@16.0.1/StreamDecoder.java:297)

```
"Monitor Ctrl-Break" #13 daemon prio=5 os_prio=0 cpu=62.50ms elapsed=42.23s tid=0x000001822e05b990 nid=0x16a8 runnable  [0x0000005f992fe000]
   java.lang.Thread.State: RUNNABLE
        at sun.nio.ch.SocketDispatcher.read0(java.base@16.0.1/Native Method)
        at sun.nio.ch.SocketDispatcher.read(java.base@16.0.1/SocketDispatcher.java:46)
        at sun.nio.ch.NioSocketImpl.tryRead(java.base@16.0.1/NioSocketImpl.java:261)
        at sun.nio.ch.NioSocketImpl.implRead(java.base@16.0.1/NioSocketImpl.java:312)
        at sun.nio.ch.NioSocketImpl.read(java.base@16.0.1/NioSocketImpl.java:350)
        at sun.nio.ch.NioSocketImpl$1.read(java.base@16.0.1/NioSocketImpl.java:803)
        at java.net.Socket$SocketInputStream.read(java.base@16.0.1/Socket.java:976)
        at sun.nio.cs.StreamDecoder.readBytes(java.base@16.0.1/StreamDecoder.java:297)
        at sun.nio.cs.StreamDecoder.implRead(java.base@16.0.1/StreamDecoder.java:339)
        at sun.nio.cs.StreamDecoder.read(java.base@16.0.1/StreamDecoder.java:188)
        - locked <0x0000000081c01950> (a java.io.InputStreamReader)
        at java.io.InputStreamReader.read(java.base@16.0.1/InputStreamReader.java:178)
        at java.io.BufferedReader.fill(java.base@16.0.1/BufferedReader.java:161)
        at java.io.BufferedReader.readLine(java.base@16.0.1/BufferedReader.java:329)
        - locked <0x0000000081c01950> (a java.io.InputStreamReader)
        at java.io.BufferedReader.readLine(java.base@16.0.1/BufferedReader.java:396)
        at com.intellij.rt.execution.application.AppMainV2$1.run(AppMainV2.java:48)

"Notification Thread" #14 daemon prio=9 os_prio=0 cpu=0.00ms elapsed=42.23s tid=0x000001822e05b440 nid=0x15fc runnable  [0x0000000000000000]
   java.lang.Thread.State: RUNNABLE

"pool-3-thread-1" #23 prio=5 os_prio=0 cpu=46.88ms elapsed=11.40s tid=0x000001822e05bee0 nid=0x49c waiting on condition  [0x0000005f97fff000]
   java.lang.Thread.State: TIMED_WAITING (sleeping)
        at java.lang.Thread.sleep(java.base@16.0.1/Native Method)
        at MultithreadedService$Task.run(MultithreadedService.java:61)
        at java.util.concurrent.ThreadPoolExecutor.runWorker(java.base@16.0.1/ThreadPoolExecutor.java:1130)
        at java.util.concurrent.ThreadPoolExecutor$Worker.run(java.base@16.0.1/ThreadPoolExecutor.java:630)
        at java.lang.Thread.run(java.base@16.0.1/Thread.java:831)

"pool-3-thread-2" #24 prio=5 os_prio=0 cpu=31.25ms elapsed=11.40s tid=0x000001822e05c980 nid=0xd68 waiting on condition  [0x0000005f995ff000]
   java.lang.Thread.State: TIMED_WAITING (sleeping)
        at java.lang.Thread.sleep(java.base@16.0.1/Native Method)
        at MultithreadedService$Task.run(MultithreadedService.java:61)
        at java.util.concurrent.ThreadPoolExecutor.runWorker(java.base@16.0.1/ThreadPoolExecutor.java:1130)
        at java.util.concurrent.ThreadPoolExecutor$Worker.run(java.base@16.0.1/ThreadPoolExecutor.java:630)
        at java.lang.Thread.run(java.base@16.0.1/Thread.java:831)

"pool-3-thread-3" #25 prio=5 os_prio=0 cpu=0.00ms elapsed=11.40s tid=0x000001822e05ced0 nid=0x2a34 waiting on condition  [0x0000005f996ff000]
   java.lang.Thread.State: TIMED_WAITING (sleeping)
        at java.lang.Thread.sleep(java.base@16.0.1/Native Method)
        at MultithreadedService$Task.run(MultithreadedService.java:61)
        at java.util.concurrent.ThreadPoolExecutor.runWorker(java.base@16.0.1/ThreadPoolExecutor.java:1130)
        at java.util.concurrent.ThreadPoolExecutor$Worker.run(java.base@16.0.1/ThreadPoolExecutor.java:630)
        at java.lang.Thread.run(java.base@16.0.1/Thread.java:831)

"pool-3-thread-4" #26 prio=5 os_prio=0 cpu=15.62ms elapsed=11.39s tid=0x000001822e05c430 nid=0x1814 waiting on condition  [0x0000005f997ff000]
   java.lang.Thread.State: TIMED_WAITING (sleeping)
        at java.lang.Thread.sleep(java.base@16.0.1/Native Method)
        at MultithreadedService$Task.run(MultithreadedService.java:61)
        at java.util.concurrent.ThreadPoolExecutor.runWorker(java.base@16.0.1/ThreadPoolExecutor.java:1130)
        at java.util.concurrent.ThreadPoolExecutor$Worker.run(java.base@16.0.1/ThreadPoolExecutor.java:630)
        at java.lang.Thread.run(java.base@16.0.1/Thread.java:831)

"VM Thread" os_prio=2 cpu=31.25ms elapsed=43.45s tid=0x000001822d538250 nid=0x10bc runnable

"GC Thread#0" os_prio=2 cpu=46.88ms elapsed=43.67s tid=0x000001820defbaf0 nid=0x1f40 runnable

"GC Thread#1" os_prio=2 cpu=15.62ms elapsed=41.16s tid=0x000001822e333550 nid=0x2430 runnable

"GC Thread#2" os_prio=2 cpu=15.62ms elapsed=41.16s tid=0x000001822e333860 nid=0x958 runnable

"GC Thread#3" os_prio=2 cpu=15.62ms elapsed=41.16s tid=0x000001822e16cf00 nid=0x266c runnable

"G1 Main Marker" os_prio=2 cpu=0.00ms elapsed=43.67s tid=0x000001820df0c7b0 nid=0x8dc runnable

"G1 Conc#0" os_prio=2 cpu=15.62ms elapsed=43.67s tid=0x000001820df0e240 nid=0x2490 runnable

"G1 Refine#0" os_prio=2 cpu=0.00ms elapsed=43.66s tid=0x000001820df84620 nid=0xc6c runnable

"G1 Service" os_prio=2 cpu=0.00ms elapsed=43.66s tid=0x000001820df860b0 nid=0x2034 runnable

"VM Periodic Task Thread" os_prio=2 cpu=15.62ms elapsed=42.20s tid=0x000001820debe1e0 nid=0x1cf0 waiting on condition

JNI global refs: 13, weak refs: 0
```