ITF23019: Parallel and Distributed Programming

Report for Lab 2: Multithreading in Java

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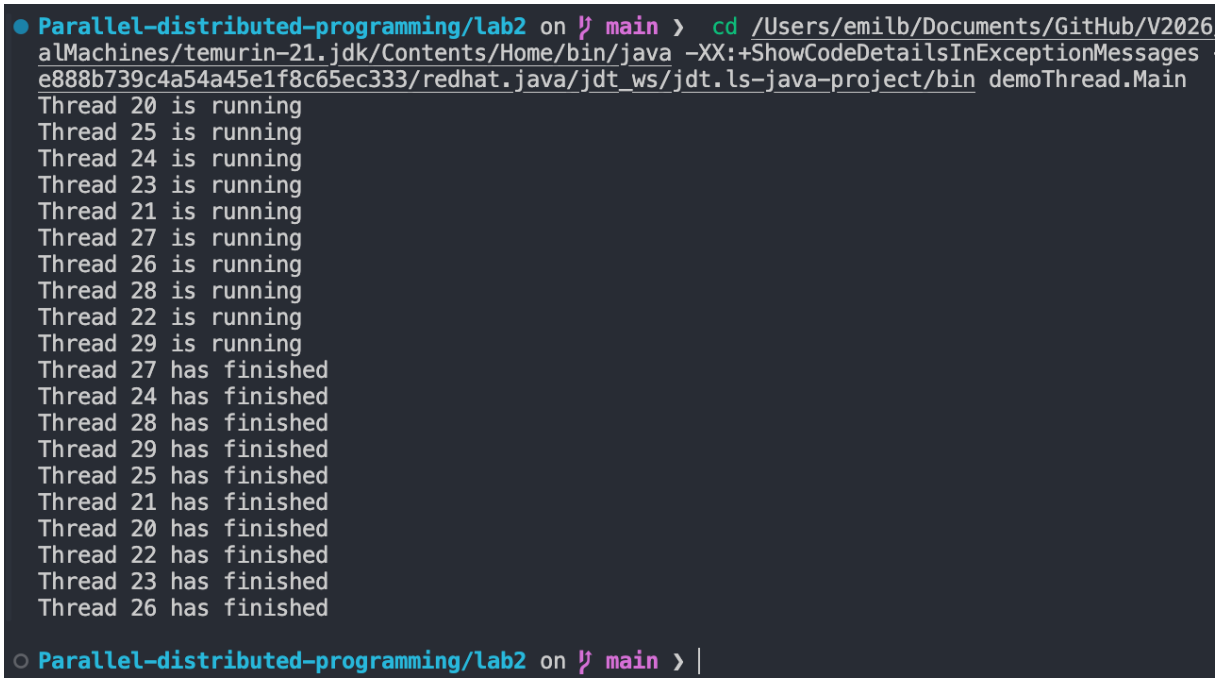
Exercise 1:

- Screenshot of the output from *demoThread:*

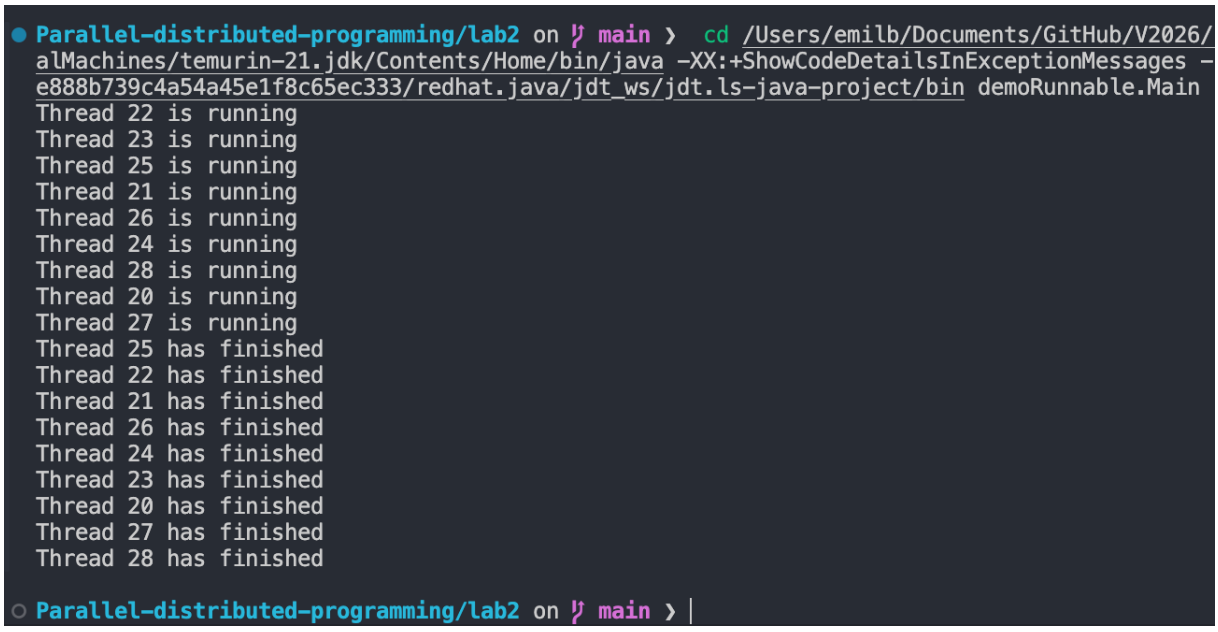


- Explanation of different output, when run several times:
    - When running *demoThread*, 10 threads get created and because threads run concurrently, their execution order is not guaranteed. The OS scheduler decides when each thread runs, sleeps, and wakes, and that can change every run. After sleeping 500 ms, threads may wake up in any order. Prints from different threads can interleave differently each time. Therefore, the output order varies from run to run.

- Explanation of why threads were not started and finished in the same order:
    - The OS scheduler chooses which thread to run, not the program. Which means starting order doesn't equal running order. A later-started thread might get CPU time before an earlier one. The 500ms sleep doesn't guarantee wake-up order. Timers are approximate and wakeups compete for CPU. So, without explicit coordination (e.g., join, locks, barriers), start and finish orders are inherently nondeterministic.

Exercise 2:

- Screenshot of the output from *DemoRunnable:*



- Explanation of different output, when run several times:
    - The outputs are different each time, mostly due to the same reasons as exercise 1. Threads are scheduled by the OS, so their execution order is not fixed, and

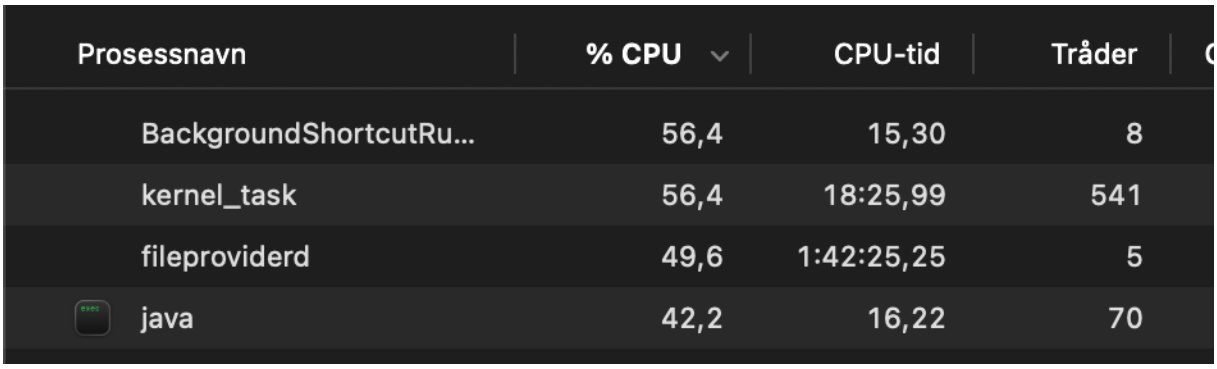
can change each run. After each sleep they also wake up in random order and then compete for CPU time.

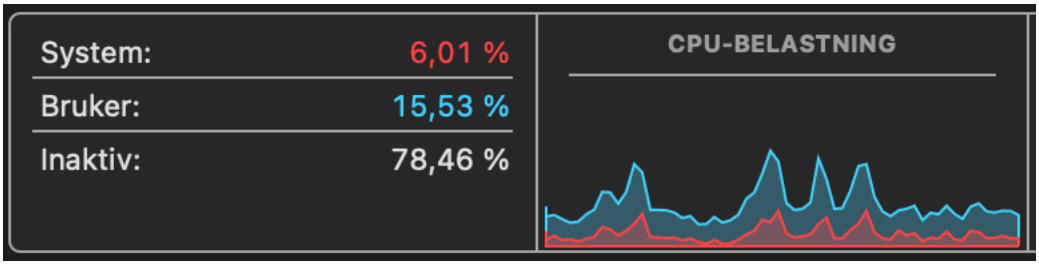
- Explanation of why threads were not started and finished in the same order:
    - The OS scheduler chooses which thread to run, not the program. Which means starting order doesn't equal running order. A later-started thread might get CPU time before an earlier one. The 500ms sleep doesn't guarantee wake-up order. Timers are approximate and wakeups compete for CPU. So, without explicit coordination (e.g., join, locks, barriers), start and finish orders are inherently nondeterministic.

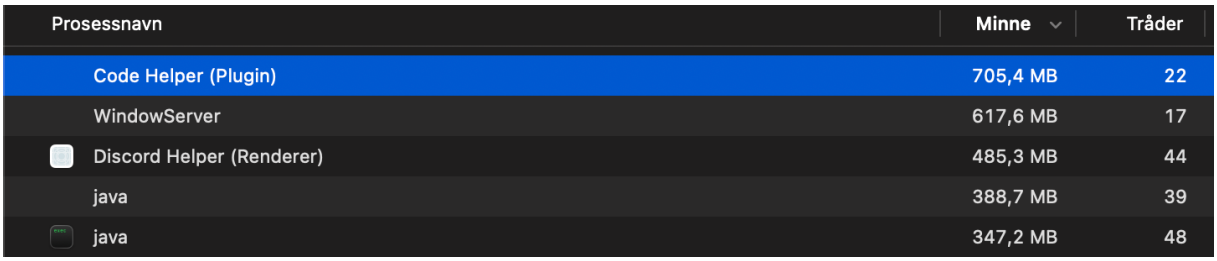
Exercise 3:

Modified number of threads from exercise 1, with effect on computer resources:

- In *DemoThreads* I tried changing the threads gradually to see how many it would take for the program. When I tried entering *n=2500* the console gave me an error before continuing. The error was a following: *Possibly out of memory or process/resource limits reached.*
- When running with 2000 threads, everything went as excepted.
- Resource-wise the computer has a CPU spike when the code is running, before it quickly dips down again. Memory/RAM wise it stays the same, this is because Visual Studio Code (IDE) and the JVM is reserving memory and not exceeding this limit.
    - Under are three figures:
    - Showing CPU usage when running the program,
    - Showing CPU spikes when running the program
    - Showing RAM usage when the code is open and running.



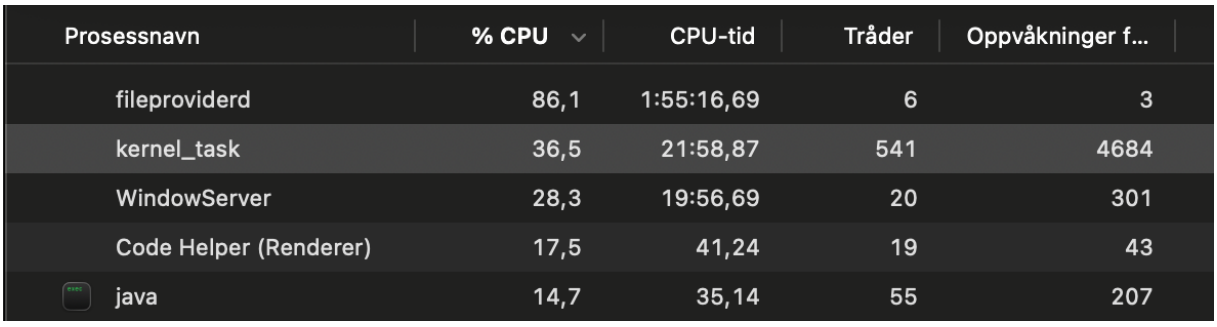




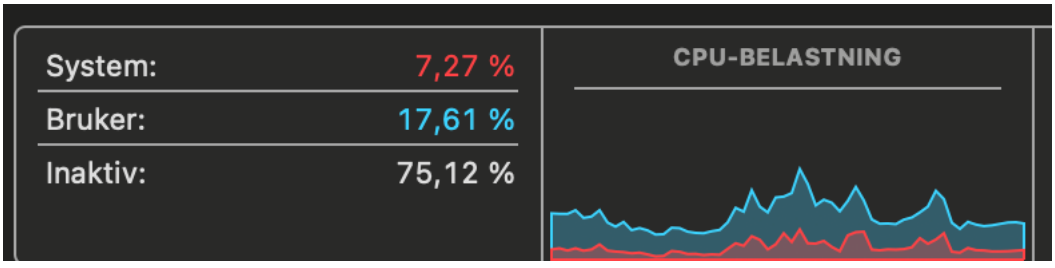
Prosessnavn	Minne	Tråder
Code Helper (Plugin)	705,4 MB	22
WindowServer	617,6 MB	17
Discord Helper (Renderer)	485,3 MB	44
java	388,7 MB	39
java	347,2 MB	48

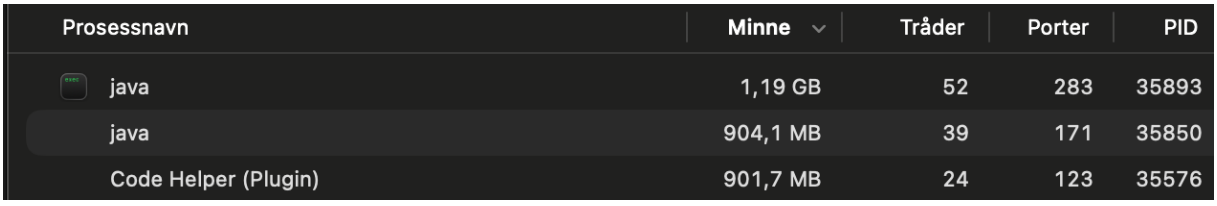
Modified number of threads from exercise 2, with effect on computer resources:

- In *DemoRunnable* I tried changing the threads gradually to see how many it would take for the program. When I tried entering *n=2500* the console gave me an error before continuing. The error was a following: *Possibly out of memory or process/resource limits reached.*
- When running with 2000 threads, everything went as excepted.
- Resource-wise the computer has a CPU spike when the code is running, before it quickly dips down again. Memory/RAM wise it stays the same, this is because Visual Studio Code (IDE) and the JVM is reserving memory and not exceeding this limit.
    - Under are three figures:
    - Showing CPU usage when running the program,
    - Showing CPU spikes when running the program
    - Showing RAM usage when the code is open and running



Prosessnavn	% CPU	CPU-tid	Tråder	Oppvåkninger f...
fileproviderd	86,1	1:55:16,69	6	3
kernel_task	36,5	21:58,87	541	4684
WindowServer	28,3	19:56,69	20	301
Code Helper (Renderer)	17,5	41,24	19	43
java	14,7	35,14	55	207





Prosessnavn	Minne	Tråder	Porter	PID
java	1,19 GB	52	283	35893
java	904,1 MB	39	171	35850
Code Helper (Plugin)	901,7 MB	24	123	35576

Exercise 4:

Extending Thread Class and creating 20 threads:

```
labs-EmilB04/lab2 on main ❯  cd /Users/emilb/Documents/GitHub/V2026/labs-EmilB04/la
brary/Java/JavaVirtualMachines/temurin-21.jdk/Contents/Home/bin/java -XX:+ShowCodeDet
es -cp /Users/emilb/Library/Application\ Support/Code/User/workspaceStorage/b7125e052
4f/redhat.java/jdt_ws/jdt.ls-java-project/bin emilbe.Main
=== Extending Thread Class - Creating 20 Threads ===

All 20 threads have been started.

Hello! Thread Name: Thread-6, Thread ID: 26, Creation Time: 19.01.2026 14:37:04
Hello! Thread Name: Thread-4, Thread ID: 24, Creation Time: 19.01.2026 14:37:04
Hello! Thread Name: Thread-14, Thread ID: 34, Creation Time: 19.01.2026 14:37:04
Hello! Thread Name: Thread-1, Thread ID: 21, Creation Time: 19.01.2026 14:37:04
Hello! Thread Name: Thread-10, Thread ID: 30, Creation Time: 19.01.2026 14:37:04
Hello! Thread Name: Thread-17, Thread ID: 37, Creation Time: 19.01.2026 14:37:04
Hello! Thread Name: Thread-16, Thread ID: 36, Creation Time: 19.01.2026 14:37:04
Hello! Thread Name: Thread-7, Thread ID: 27, Creation Time: 19.01.2026 14:37:04
Hello! Thread Name: Thread-15, Thread ID: 35, Creation Time: 19.01.2026 14:37:04
Hello! Thread Name: Thread-5, Thread ID: 25, Creation Time: 19.01.2026 14:37:04
Hello! Thread Name: Thread-13, Thread ID: 33, Creation Time: 19.01.2026 14:37:04
Hello! Thread Name: Thread-2, Thread ID: 22, Creation Time: 19.01.2026 14:37:04
Hello! Thread Name: Thread-0, Thread ID: 20, Creation Time: 19.01.2026 14:37:04
Hello! Thread Name: Thread-19, Thread ID: 39, Creation Time: 19.01.2026 14:37:04
Hello! Thread Name: Thread-3, Thread ID: 23, Creation Time: 19.01.2026 14:37:04
Hello! Thread Name: Thread-12, Thread ID: 32, Creation Time: 19.01.2026 14:37:04
Hello! Thread Name: Thread-8, Thread ID: 28, Creation Time: 19.01.2026 14:37:04
Hello! Thread Name: Thread-18, Thread ID: 38, Creation Time: 19.01.2026 14:37:04
Hello! Thread Name: Thread-11, Thread ID: 31, Creation Time: 19.01.2026 14:37:04
Hello! Thread Name: Thread-9, Thread ID: 29, Creation Time: 19.01.2026 14:37:04
Thread Thread-7 terminating at: 19.01.2026 14:37:04
Thread Thread-2 terminating at: 19.01.2026 14:37:04
Thread Thread-18 terminating at: 19.01.2026 14:37:04
Thread Thread-9 terminating at: 19.01.2026 14:37:04
Thread Thread-11 terminating at: 19.01.2026 14:37:04
Thread Thread-16 terminating at: 19.01.2026 14:37:04
Thread Thread-6 terminating at: 19.01.2026 14:37:04
Thread Thread-5 terminating at: 19.01.2026 14:37:04
Thread Thread-17 terminating at: 19.01.2026 14:37:04
Thread Thread-1 terminating at: 19.01.2026 14:37:04
Thread Thread-14 terminating at: 19.01.2026 14:37:04
Thread Thread-15 terminating at: 19.01.2026 14:37:04
Thread Thread-4 terminating at: 19.01.2026 14:37:04
Thread Thread-8 terminating at: 19.01.2026 14:37:04
Thread Thread-13 terminating at: 19.01.2026 14:37:04
Thread Thread-19 terminating at: 19.01.2026 14:37:04
Thread Thread-0 terminating at: 19.01.2026 14:37:04
Thread Thread-10 terminating at: 19.01.2026 14:37:04
Thread Thread-3 terminating at: 19.01.2026 14:37:04
Thread Thread-12 terminating at: 19.01.2026 14:37:04

labs-EmilB04/lab2 on main ❯
```

Implementing Runnable Interface and creating 20 threads:

```
labs-EmilB04/lab2 on  main ❯  cd /Users/emilb/Documents/GitHub/V2026/labs-EmilB04/la
brary/Java/JavaVirtualMachines/temurin-21.jdk/Contents/Home/bin/java -XX:+ShowCodeDet
tionMessages -cp /Users/emilb/Library/Application\ Support/Code/User/workspaceStorage
3f1e4d41d24f/redhat.java/jdt_ws/jdt.ls-java-project/bin emilbe.implementsRun.Main
=== Implementing Runnable Interface - Creating 20 Threads ===

All 20 threads have been started.

Hello! Thread Name: Thread-10, Thread ID: 30, Creation Time: 19.01.2026 14:34:41
Hello! Thread Name: Thread-18, Thread ID: 38, Creation Time: 19.01.2026 14:34:41
Hello! Thread Name: Thread-5, Thread ID: 25, Creation Time: 19.01.2026 14:34:41
Hello! Thread Name: Thread-7, Thread ID: 27, Creation Time: 19.01.2026 14:34:41
Hello! Thread Name: Thread-8, Thread ID: 28, Creation Time: 19.01.2026 14:34:41
Hello! Thread Name: Thread-6, Thread ID: 26, Creation Time: 19.01.2026 14:34:41
Hello! Thread Name: Thread-3, Thread ID: 23, Creation Time: 19.01.2026 14:34:41
Hello! Thread Name: Thread-1, Thread ID: 21, Creation Time: 19.01.2026 14:34:41
Hello! Thread Name: Thread-2, Thread ID: 22, Creation Time: 19.01.2026 14:34:41
Hello! Thread Name: Thread-14, Thread ID: 34, Creation Time: 19.01.2026 14:34:41
Hello! Thread Name: Thread-19, Thread ID: 39, Creation Time: 19.01.2026 14:34:41
Hello! Thread Name: Thread-11, Thread ID: 31, Creation Time: 19.01.2026 14:34:41
Hello! Thread Name: Thread-0, Thread ID: 20, Creation Time: 19.01.2026 14:34:41
Hello! Thread Name: Thread-16, Thread ID: 36, Creation Time: 19.01.2026 14:34:41
Hello! Thread Name: Thread-9, Thread ID: 29, Creation Time: 19.01.2026 14:34:41
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Hello! Thread Name: Thread-13, Thread ID: 33, Creation Time: 19.01.2026 14:34:41
Thread Thread-11 terminating at: 19.01.2026 14:34:41
Thread Thread-15 terminating at: 19.01.2026 14:34:41
Thread Thread-2 terminating at: 19.01.2026 14:34:41
Thread Thread-14 terminating at: 19.01.2026 14:34:41
Thread Thread-12 terminating at: 19.01.2026 14:34:41
Thread Thread-3 terminating at: 19.01.2026 14:34:41
Thread Thread-6 terminating at: 19.01.2026 14:34:41
Thread Thread-19 terminating at: 19.01.2026 14:34:41
Thread Thread-1 terminating at: 19.01.2026 14:34:41
Thread Thread-9 terminating at: 19.01.2026 14:34:41
Thread Thread-13 terminating at: 19.01.2026 14:34:41
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Thread Thread-17 terminating at: 19.01.2026 14:34:41
Thread Thread-10 terminating at: 19.01.2026 14:34:41
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Thread Thread-8 terminating at: 19.01.2026 14:34:41
Thread Thread-16 terminating at: 19.01.2026 14:34:41
Thread Thread-5 terminating at: 19.01.2026 14:34:41
Thread Thread-18 terminating at: 19.01.2026 14:34:41

labs-EmilB04/lab2 on  main ❯
```