Laboratory report

EOPSY LAB 3

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Gitlab: https://gitlab-stud.elka.pw.edu.pl/pborsuki/eopsy-lab3.git

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Introduction

Scheduling is a way of optimizing work of the computer by arranging particular order of operations. We need scheduling to avoid wasting CPU time. When a process is waiting for I/O we may start execution of other process in the meantime.

So as to make scheduling work properly we should have in mind that we want to achieve some of the following goals:

- provide maximal CPU utilization possible while
- having fair allocation
- have minimal response time
- have minimal wait time in ready queue
- have maximal number of processes finished in a given time

Depending on what we want to achieve we may choose various scheduling algorithms.

First of them is FCFS (first come first served). It is implemented using queue based on FIFO (first in first out) and allocates CPU to the process that asked for it first. When a process enters a ready queue it is attached to the end of the queue to await execution. This algorithm has a drawback in a form of convoy effect, where system slows down due to need of execution a long tasks before a set of smaller tasks.

Further, we may want to avoid convoy effect by choosing SFJ (shortest job first) algorithm. In this algorithm processes are ranked by their execution time and the ones that can be finished the fastest are executed first. In case of the tie, FCFS rules are used.

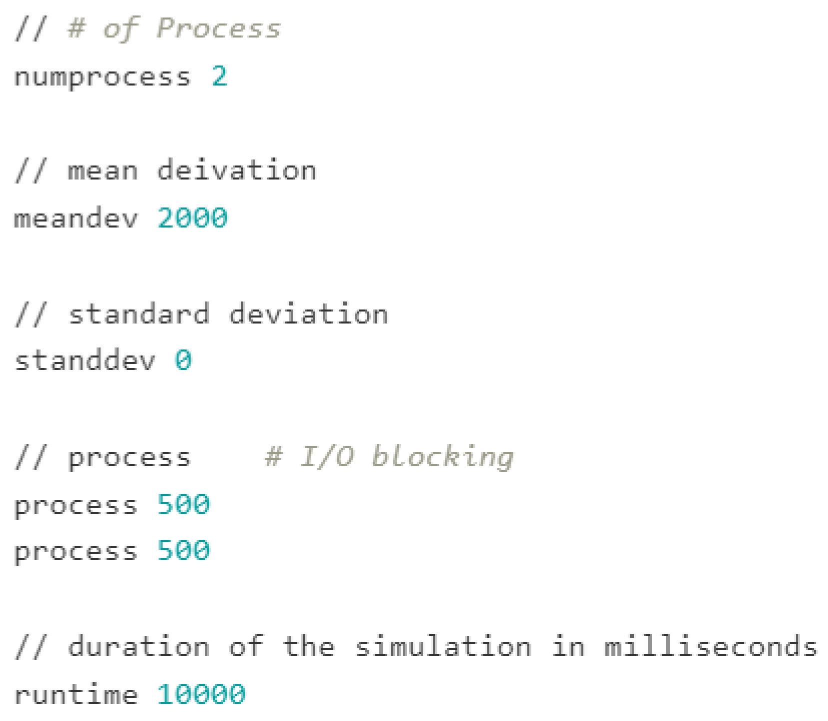
In some specific cases we may want to use LJF (longest job first) algorithm, which gives priority to processes that have the highest execution time.

There are also variants based on the remaining time – either shortest (STRF – shortest remaining time first) or longest (LTRF – longest remaining time first).

One may also implement algorithms based on process priority, however, this algorithms give a risk of starvation – some processes may never be executed.

Task 1.

For the purpose of the exercise, following parameters were to be set:



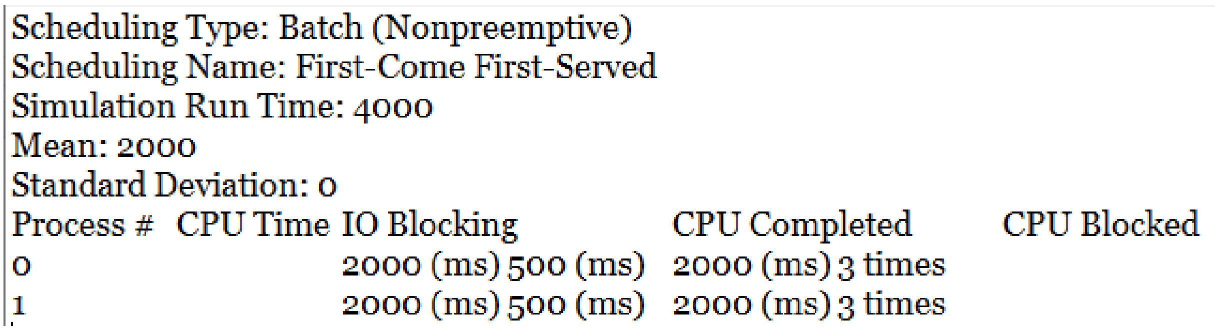
```
// # of Process
numprocess 2

// mean deivation
meandev 2000

// standard deviation
standdev 0

// process    # I/O blocking
process 500
process 500

// duration of the simulation in milliseconds
runtime 10000
```

Figure 1. Initial configuration

It can be observed that the whole simulation is supposed to end after 10000 milliseconds, mean time of program execution is 2000 milliseconds with standard deviation equal to 0 which means that all processes should end exactly after 2000 milliseconds of execution.

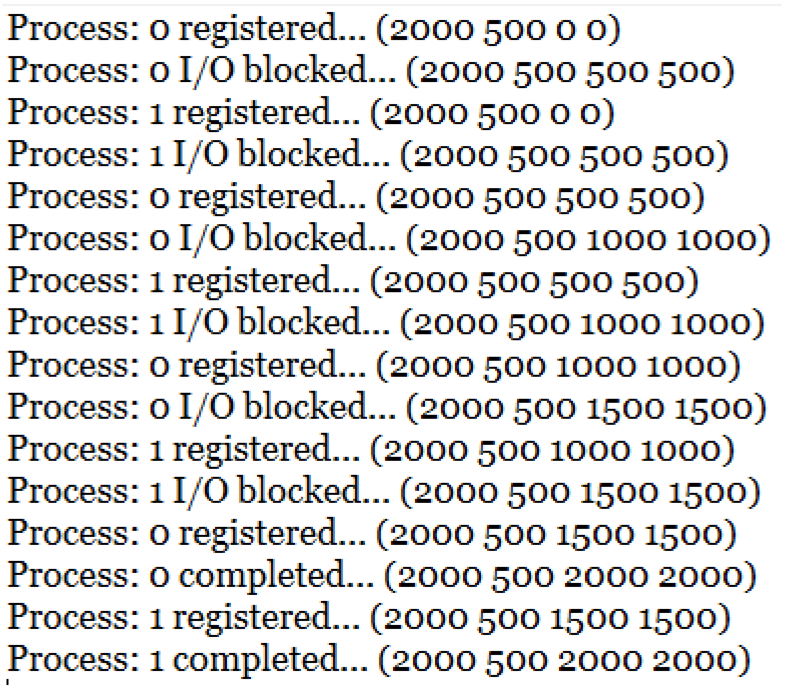
Part 1. 2 processes

For this part of the exercise initial setup was used. Number of processes was set to 2 and they are blocked for input or output after 500 milliseconds of execution.



```
Scheduling Type: Batch (Nonpreemptive)
Scheduling Name: First-Come First-Served
Simulation Run Time: 4000
Mean: 2000
Standard Deviation: 0
Process #  CPU Time IO Blocking        CPU Completed       CPU Blocked
0                   2000 (ms) 500 (ms)  2000 (ms) 3 times
1                   2000 (ms) 500 (ms)  2000 (ms) 3 times
```

Figure 2. Summary-Results output file

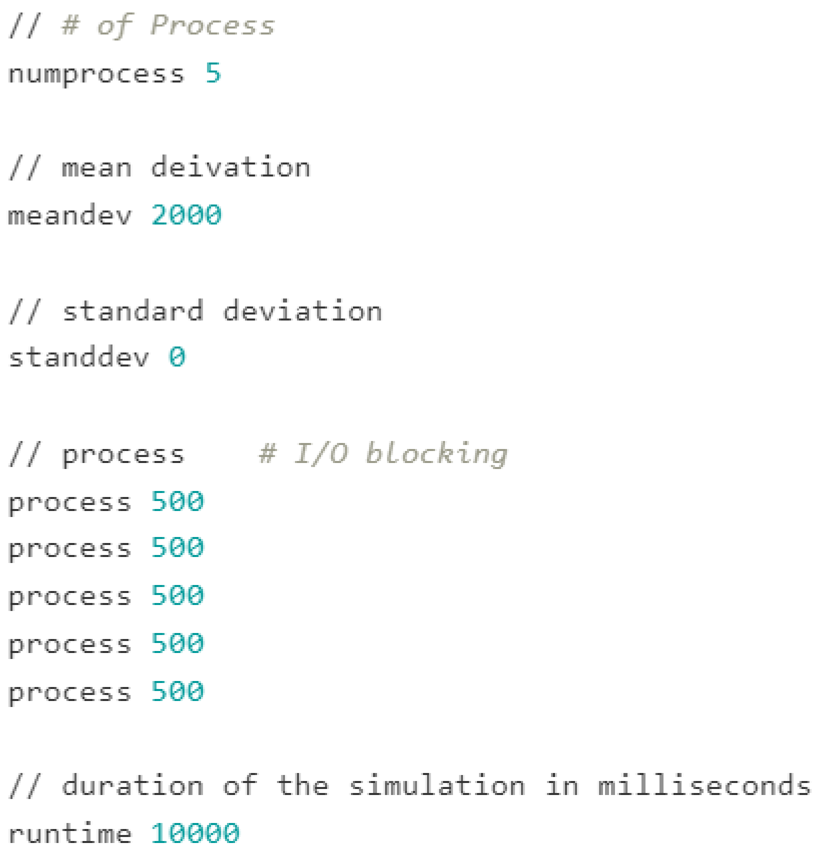


```
Process: 0 registered... (2000 500 0 0)
Process: 0 I/O blocked... (2000 500 500 500)
Process: 1 registered... (2000 500 0 0)
Process: 1 I/O blocked... (2000 500 500 500)
Process: 0 registered... (2000 500 500 500)
Process: 0 I/O blocked... (2000 500 1000 1000)
Process: 1 registered... (2000 500 500 500)
Process: 1 I/O blocked... (2000 500 1000 1000)
Process: 0 registered... (2000 500 1000 1000)
Process: 0 I/O blocked... (2000 500 1500 1500)
Process: 1 registered... (2000 500 1000 1000)
Process: 1 I/O blocked... (2000 500 1500 1500)
Process: 0 registered... (2000 500 1500 1500)
Process: 0 completed... (2000 500 2000 2000)
Process: 1 registered... (2000 500 1500 1500)
Process: 1 completed... (2000 500 2000 2000)
```

Figure 3. Summary-Process output file

Unsurprisingly, as it can be observed on figure 2, program finished execution after 4000 millisecond (2 processes * 2000 milliseconds per process) and I/O was blocked 3 times per process. It makes sense as processes were stopped after 500, 1000 and 1500 milliseconds of their execution. There was no need to block them at 2000 milliseconds as it was the very time when they were completed. Analyzing figure 3, one may confirm those findings, but also observe the pattern in which processes were executed. Firstly, process 0 was registered and it was executed for 500ms, then it was blocked and process 1 was registered and was allowed execution for 500ms. The routine of registering and blocking was looped 3 times. After 500ms after 4th registering of process 0, it was declared as completed (as 2000ms has passed) and process 1 was registered without blocking I/O from process 0 (it has already terminated). After 500ms process 1 was completed and the whole simulation was terminated as all processes have terminated.

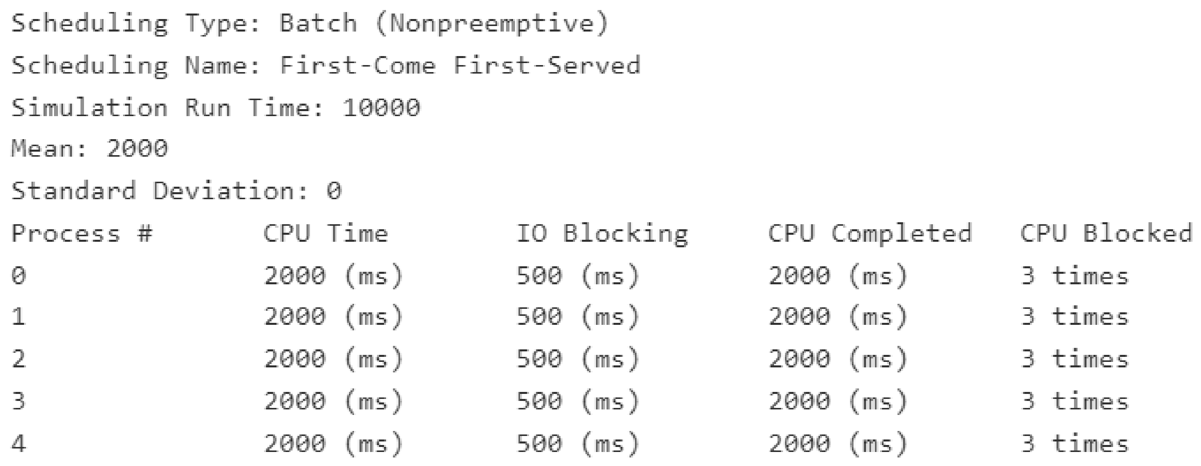
Part 2. 5 processes



```
// # of Process
numprocess 5

// mean deivation
meandev 2000

// standard deviation
standdev 0

// process    # I/O blocking
process 500
process 500
process 500
process 500
process 500

// duration of the simulation in milliseconds
runtime 10000
```

Figure 4. Configuration for 5 processes

In this part of the task, number of processes was to be increased to 5.



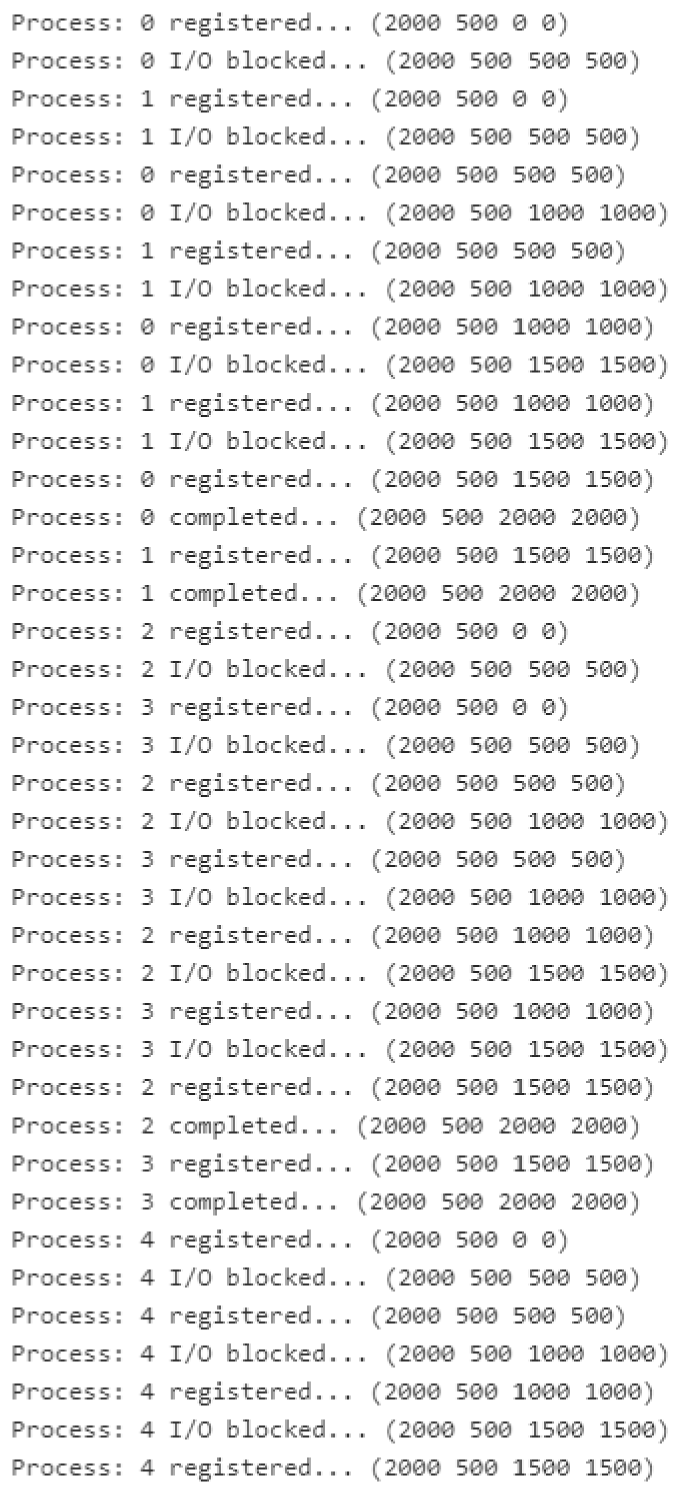
```
Scheduling Type: Batch (Nonpreemptive)
Scheduling Name: First-Come First-Served
Simulation Run Time: 10000
Mean: 2000
Standard Deviation: 0
Process #       CPU Time        IO Blocking     CPU Completed   CPU Blocked
0               2000 (ms)       500 (ms)        2000 (ms)       3 times
1               2000 (ms)       500 (ms)        2000 (ms)       3 times
2               2000 (ms)       500 (ms)        2000 (ms)       3 times
3               2000 (ms)       500 (ms)        2000 (ms)       3 times
4               2000 (ms)       500 (ms)        2000 (ms)       3 times
```

Figure 5. Summary-Results output file for 5 processes

As it can be observed on figure 5, full simulation time was needed to execute all 5 processes (5*2000ms = 10000ms). Similarly to the results of the previous subtask, each process was blocked 3 times, after each 500ms of execution.

Nonetheless, important patterns can be observed only on figure 6 presented below. From that figure we can learn that after 500ms I/O is blocked for process 0 and process 1 is executed. However, after another 500ms CPU time is not given to process 2, but to process 0 as we operate in scheduling system "First-Come First-Served", which intends to finish the oldest process as fast as possible giving it CPU time whenever possible. For the same reason, after I/O block of process 0 it is process 1 that is given CPU time. Therefore, process 2 starts its execution after 4000ms of simulation start as until that time CPU time was used only by processes 0 and 1 in a form of the loop described in part 1 of this report. Then between 4000ms and 8000ms after program start the same loop is repeated, but for processes 2 and 3. At the end, when there is only one process left to execute it is provided all CPU time (after each I/O block process 4 regains its CPU time) until 10000ms timestamp when it should finish its execution, however the figure 6 does not show information that it was completed even though according to figure 5 it was provided 2000ms of CPU time. It is possible that the simulation end happens before the process end when they are terminated at the same time.

FCFS is a non-preemptive algorithm, which means that it is not allocated limited time (preemptive scheduling), but rather it is executed until it is terminated or reaches waiting state (for example I/O block).

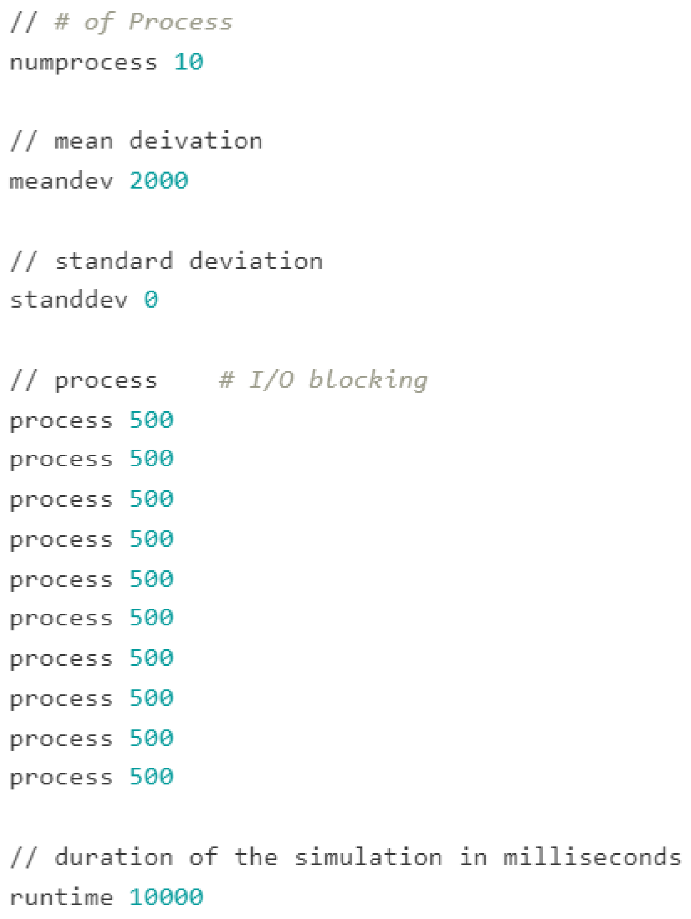


```
Process: 0 registered... (2000 500 0 0)
Process: 0 I/O blocked... (2000 500 500 500)
Process: 1 registered... (2000 500 0 0)
Process: 1 I/O blocked... (2000 500 500 500)
Process: 0 registered... (2000 500 500 500)
Process: 0 I/O blocked... (2000 500 1000 1000)
Process: 1 registered... (2000 500 500 500)
Process: 1 I/O blocked... (2000 500 1000 1000)
Process: 0 registered... (2000 500 1000 1000)
Process: 0 I/O blocked... (2000 500 1500 1500)
Process: 1 registered... (2000 500 1000 1000)
Process: 1 I/O blocked... (2000 500 1500 1500)
Process: 0 registered... (2000 500 1500 1500)
Process: 0 completed... (2000 500 2000 2000)
Process: 1 registered... (2000 500 1500 1500)
Process: 1 completed... (2000 500 2000 2000)
Process: 2 registered... (2000 500 0 0)
Process: 2 I/O blocked... (2000 500 500 500)
Process: 3 registered... (2000 500 0 0)
Process: 3 I/O blocked... (2000 500 500 500)
Process: 2 registered... (2000 500 500 500)
Process: 2 I/O blocked... (2000 500 1000 1000)
Process: 3 registered... (2000 500 500 500)
Process: 3 I/O blocked... (2000 500 1000 1000)
Process: 2 registered... (2000 500 1000 1000)
Process: 2 I/O blocked... (2000 500 1500 1500)
Process: 3 registered... (2000 500 1000 1000)
Process: 3 I/O blocked... (2000 500 1500 1500)
Process: 2 registered... (2000 500 1500 1500)
Process: 2 completed... (2000 500 2000 2000)
Process: 3 registered... (2000 500 1500 1500)
Process: 3 completed... (2000 500 2000 2000)
Process: 4 registered... (2000 500 0 0)
Process: 4 I/O blocked... (2000 500 500 500)
Process: 4 registered... (2000 500 500 500)
Process: 4 I/O blocked... (2000 500 1000 1000)
Process: 4 registered... (2000 500 1000 1000)
Process: 4 I/O blocked... (2000 500 1500 1500)
Process: 4 registered... (2000 500 1500 1500)
```

Figure 6. Summary-Processes output file for 5 processes

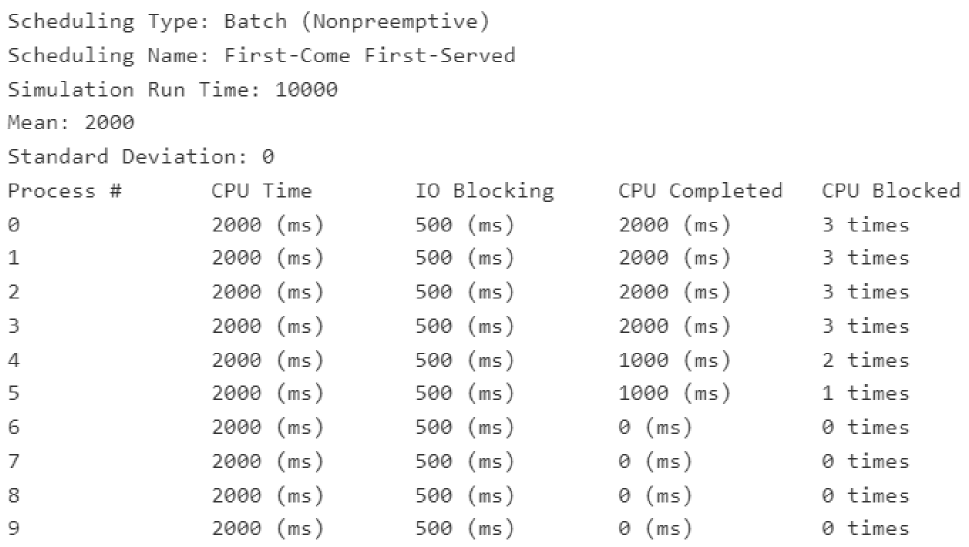
Part 3. 10 processes

In this part of the task, number of processes was to be increased to 10.



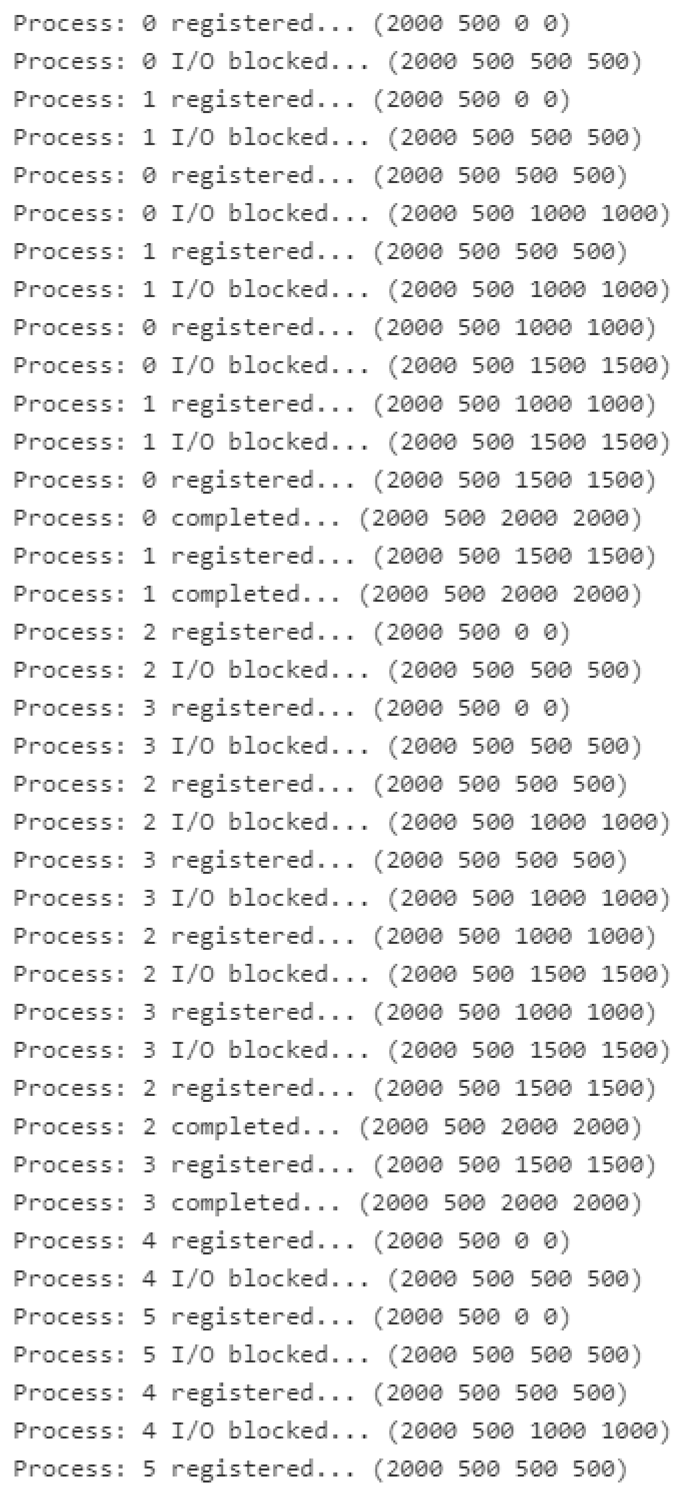
```
// # of Process
numprocess 10

// mean deivation
meandev 2000

// standard deviation
standdev 0

// process    # I/O blocking
process 500
process 500
process 500
process 500
process 500
process 500
process 500
process 500
process 500
process 500

// duration of the simulation in milliseconds
runtime 10000
```

Figure 7. Configuration for 10 processes



```
Scheduling Type: Batch (Nonpreemptive)
Scheduling Name: First-Come First-Served
Simulation Run Time: 10000
Mean: 2000
Standard Deviation: 0
Process #	CPU Time	IO Blocking	CPU Completed	CPU Blocked
0		2000 (ms)	500 (ms)	2000 (ms)	3 times
1		2000 (ms)	500 (ms)	2000 (ms)	3 times
2		2000 (ms)	500 (ms)	2000 (ms)	3 times
3		2000 (ms)	500 (ms)	2000 (ms)	3 times
4		2000 (ms)	500 (ms)	1000 (ms)	2 times
5		2000 (ms)	500 (ms)	1000 (ms)	1 times
6		2000 (ms)	500 (ms)	0 (ms)		0 times
7		2000 (ms)	500 (ms)	0 (ms)		0 times
8		2000 (ms)	500 (ms)	0 (ms)		0 times
9		2000 (ms)	500 (ms)	0 (ms)		0 times
```

Figure 8. Summary-Results output file for 10 processes



```
Process: 0 registered... (2000 500 0 0)
Process: 0 I/O blocked... (2000 500 500 500)
Process: 1 registered... (2000 500 0 0)
Process: 1 I/O blocked... (2000 500 500 500)
Process: 0 registered... (2000 500 500 500)
Process: 0 I/O blocked... (2000 500 1000 1000)
Process: 1 registered... (2000 500 500 500)
Process: 1 I/O blocked... (2000 500 1000 1000)
Process: 0 registered... (2000 500 1000 1000)
Process: 0 I/O blocked... (2000 500 1500 1500)
Process: 1 registered... (2000 500 1000 1000)
Process: 1 I/O blocked... (2000 500 1500 1500)
Process: 0 registered... (2000 500 1500 1500)
Process: 0 completed... (2000 500 2000 2000)
Process: 1 registered... (2000 500 1500 1500)
Process: 1 completed... (2000 500 2000 2000)
Process: 2 registered... (2000 500 0 0)
Process: 2 I/O blocked... (2000 500 500 500)
Process: 3 registered... (2000 500 0 0)
Process: 3 I/O blocked... (2000 500 500 500)
Process: 2 registered... (2000 500 500 500)
Process: 2 I/O blocked... (2000 500 1000 1000)
Process: 3 registered... (2000 500 500 500)
Process: 3 I/O blocked... (2000 500 1000 1000)
Process: 2 registered... (2000 500 1000 1000)
Process: 2 I/O blocked... (2000 500 1500 1500)
Process: 3 registered... (2000 500 1000 1000)
Process: 3 I/O blocked... (2000 500 1500 1500)
Process: 2 registered... (2000 500 1500 1500)
Process: 2 completed... (2000 500 2000 2000)
Process: 3 registered... (2000 500 1500 1500)
Process: 3 completed... (2000 500 2000 2000)
Process: 4 registered... (2000 500 0 0)
Process: 4 I/O blocked... (2000 500 500 500)
Process: 5 registered... (2000 500 0 0)
Process: 5 I/O blocked... (2000 500 500 500)
Process: 4 registered... (2000 500 500 500)
Process: 4 I/O blocked... (2000 500 1000 1000)
Process: 5 registered... (2000 500 500 500)
```

Figure 9. Summary-Processes output file for 10 processes

Not surprisingly, as it can be observed on figure 8, not all processes were executed. 10s is not enough to executed 10 process, 2s each. What is interesting, is that there were 2 processes (4 and 5) that were only partially executed. It was due to the fact that our processes were executed in pairs in the very same way as in previous subtasks due to "First-Come First-Served" rule. Pairs were process 0 and process 1, process 2 and process 3, and so on. Each pair requires 4000ms to be fully executed with 3 I/O blocks per process. Therefore process 0-3 were fully executed after 8000ms. The remaining 2000ms of CPU time was divided between processes 4 and 5. Process 4 started at 8000ms timestamp and was blocked at 8500ms and then at 9500ms. Process 5 was only blocked at 9000ms as the simulation terminated after 10000ms. If simulation had more time, we would observe I/O blocked for process 5 at 10000ms timestamp. Following pair of processes – 6 and 7 would start operation at 12000ms timestamp with execution of process 6, however, it was never meant to happen as simulation ends after 10000ms. Similarly, due to the same reasons processes 8 and 9 were not even started.